Graph Theory and Universal Grammar

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> "…Forse non tutto il male viene per nuocere, una visione parziale non è di per sé negativa, basta che sia esplicita e non abbia la pretesa di esaurire l'argomento […] Senza poi escludere che siano i mestieri di neuroscienziato e di linguista a essere vecchi: non è detto che non ne debba nascere uno nuovo".

Un bello stimolo. Una bella sfida possibile.

Da ultimo una speranza: mi auguro che il mio pseudo-inglese, da qui in avanti, assomigli il più possibile ad una lingua naturale.

Questa tesi è dedicata a mia moglie Salomé, straordinaria ogni giorno di più:
senza di lei avrei perso il fil-o.

ABSTRACT

In the last few years, Noam Chomsky (1994; 1995; 2000; 2001) has gone quite far in the direction of simplifying syntax, including eliminating X-bar theory and the levels of D-structure and S-structure entirely, as well as reducing movement rules to a combination of the more primitive operations of Copy and Merge. What remain in the Minimalist Program are the operations Merge and Agree and the levels of LF (Logical Form) and PF (Phonological form).

My doctoral thesis attempts to offer an economical theory of syntactic structure from a graph-theoretic point of view (cf. Diestel, 2005), with special emphases on the elimination of category and projection labels and the Inclusiveness Condition (Chomsky 1994). The major influences for the development of such a theory have been Chris Collins' (2002) seminal paper "Eliminating labels", John Bowers (2001) unpublished manuscript "Syntactic Relations" and the Cartographic Paradigm (see Belletti, Cinque and Rizzi's volumes on OUP for a starting point regarding this paradigm).

A syntactic structure will be regarded here as a graph consisting of the set of lexical items, the set of relations among them and nothing more.

Quotes

“Any inference rule can be non-trivially revised so that one fails to accept it where one once accepted it, or vice versa.”

W.V. Quine

"Graphics reveal data."

E. Tufte

Preface / Guidelines

This work consists of six chapters.

In the first chapter I introduce how topologic networks could be useful for a wide range of cognitive matters, from a theoretic perspective, given some basic principles. I introduce as well the fascinating hypothesis of a topological and *viral* nature of language (spreading linguistic variation) made up by Piattelli Palmarini & Uriagereka in 2004.

Then, I review the idea of David B. Searls who claims that many techniques used in bioinformatics and genetics, even if developed independently, may be seen to be grounded in generative linguistics and, symmetrically, the discover of a "language" gene: *FOXP2*. These discoveries (or beliefs) are reported here to show how fruitful could be a cross-disciplinary attitude in the search for the *innermost* nature of Language. That's also the main reason for which I have tried to apply some basic principles of Graph Theory to Minimalist principles.

The last section of the chapter is a rough historical survey (mainly based on Wildgen, 1994, 2000) of a "topological" way of thinking among human sciences, from Lullus, Bruno and Leibniz to Fillmore, Minsky and Langacker. Note that the first chapter is intended to be *quite* light and does not require a *narrow* competence in the field of generative linguistics.

In the second chapter "Graphs and Transformations" I give a survey of some essentials of Graph Theory from a mathematical point of view, with major emphases on graph transformations including a translation of Chomsky grammars into graph grammars, showing the computational completeness of graph transformation.

Unfortunately, graphs are quite generic structures that can be encountered in many variants in the literature, and there are also many ways to apply rules to graphs. One cannot deal with all possibilities in a basic survey and it would also go beyond the *scope* of my work. I focus on directed graphs (syntactic trees are a special kind of directed, *label-edged* graphs), because the directed graphs can be specialized into many other types of graphs, and I define graph grammars as a language-generating device with the more general notion of a transformation unit that models *binary* relations on graphs.

Chapter three "From bare phrase structure to syntactic graphs" is the *core* of the work with the graph theoretic (re)definition of internal and external MERGE and the explanation of the way lexical graphs could capture constituency, C-command and other important syntactic relations expressed in standard tree representations (assuming for example that different PF interpretations could be elegantly derived *via* syntactic graphs using traversal algorithms developed by Yasui (2004a,b)).

I also introduce in this section other theoretical issues regarding a label-free syntax, such as the ones developed by Chris Collins (2001; 2002), John Bowers (2001), and Joan Chen-Main (2006). Finally, I outline some *light* similarities of Brody's Mirror Theory (1997) with my proposal.

Chapter four "Topics of Persian Syntax and a graph based analysis of Persian Ezafe" introduces some challenging issues of Persian grammar and develops a graph based account of the "Ezafe puzzle" in Western Indo-iranian languages, in which NP modifiers standardly occur postnominally and "link" to the noun head via an Ezafe particle (Ez), which may be invariant (Persian, Sorani), or agree with N in *ϕ-features* (Kurmanji, Zazaki). We will use in our research the precious cross-linguistical data collected by Larson and Yamakido (2005; 2006) and Samvelian (2006).

After a basic (but articulated) sketch of Persian syntax, with major emphases on some syntactic aspects that I have already considered in previous works, such as word order and split-*headness*, Inverse Case Attraction of Persian relative clauses and Persian light verb constructions which seems to be an *ouvert* instance of Hale and Keyser (1993; 2002) compositional syntactic analysis (without theta-roles) of Argument Structure (see also Harley, Folli, Karimi, 2003), I give a detailed review of previous analyses of the Ezafe morpheme in the generative framework (cfr. Samiiam, 1983; 1994; Ghomeshi, 1997; Kahnemuyipour, 2000; Franco, 2004; Larson and Yamakido, 2005; Samvelian; 2006 among others) and I develop here a graph analysis of the Ezafe phenomenon based on Den Dikken and Singhapreecha (2004), where the authors give a cross-linguistic account (the point of departure for them was the comparison between French and Thai) of the noun phrases in which linkers occur, in terms of DP-internal Predicate Inversion (see also Moro, 1997; 2000). This approach prompts an analysis of relative-clause constructions that recognizes relative clauses as predicates of DP-internal small clauses, combining the attractions of the traditional approach and the Vergnaud/Kayne raising approach by assigning relative clauses an internal structure similar to the traditional one while giving it the external distribution of a predicate by treating it as the predicate of a noun phrase-internal small clause. In other words, we could say that a sort of *Generalized Predicate Inversion* in the Persian complex noun phrase is marked by the presence of the Ezafe mopheme.

In a graph theoretic perspective the assumption that a syntactic element could be interpreted as a *linker*, implies the theoretical necessity that certain linguistic items could be selected by the Lexicon as Edges (E), instead of vertexes (V) and this is a stimulating fact.

The fifth chapter is a ground for some (possible and extreme) theoretical consequences of a graph theoretic analysis of language faculty.

The Conclusion follows.

This work also has three appendixes. The first involve the field of logics and is a rough review of Charles Sanders Peirce's existential graphs (based mainly on Proni, 1992); the second is far more near to the questions and answers raised in this work, and has a straight linguistic topic, showing some of the most interesting dynamics of the Relational Grammar Paradigm established in the seventies by Perlmutter and Postal. Finally the third appendix is a brief application of a Graph theoretic derivation to an Austronesian Language (Tagalog).

Chapter 1.
Topological Networks and Cognitive Science

In this chapter I try to demonstrate how *topologic networks* could be fruitful for a wide range of cognitive issues, from a theoretic perspective, given some basic principles. I introduce also the fascinating hypothesis of a topological and *viral* nature of language made up by Piattelli Palmarini & Uriagereka in 2004.

Then, I review the idea of David B. Searls who claims that many techniques used in bioinformatics and genetics, even if developed independently, may be seen to be grounded in generative linguistics and, symmetrically, the discover of a "language" gene: FOXP2 (cf. Lai *et al.* 2001). These beliefs are reported here to show how useful could be a cross-disciplinary attitude in the search for the evolution of the human faculty of language. That's also one of the main reasons for which I have tried to apply Graph Theory to Minimalism.

The last section of the chapter is a rough historical survey of a "topological" way of thinking among philosophy of language, from Lullus, Bruno and Leibniz to Fillmore, Minsky and Langacker. As I have already mentioned in the preface of the work, this chapter is intended to be *light* and does not require a *specific* competence in the field of generative linguistics (except, *maybe*, paragraph 1.2).

1.1 Beyond a metaphor: topology as a theoretical basis for cognitive science

In talking somewhat roughly of "topological foundations for cognitive science", I am arguing that the topological approach yields not simply a collection of insights and methods in selected fields, but a unifying framework for a range of different types of research across the breadth of cognitive science and a sort of *common language* for the formulation of hypotheses drawn from a variety of (seemingly) disparate fields (from biology to linguistics). Indeed, certain characteristics of contemporary thinking, related to that general *trend* usually called "post-modernist thinking" - visible in such things as a *vaguer* but at the same time *subtler* way of tackling complex problems, recognizing the role of variation etc., and also a generalization of a topological way of thinking - are shared (cf. Sporns *et al*. 2004).

A preliminary evidence for the correctness of this kind of view is provided not just by the *scope* of the inquiries of a wide range of disciplines, but also by the *degree* to which, in different ways, they "overlap" amongst themselves and support each other in a mutual way.

A thought behind the idea that the "inventory" of *topological* concepts can yield a unifying framework for cognitive science turns on the fact that, as has often been pointed out (cf. Gibson, 1986), things such as *boundaries*, for example, are centre of salience not only in a spatial but also in a temporal world (the beginnings and endings (the *aspect*) of events, the boundaries of qualitative changes for example in the unfolding of speech events (cf. Petitot, 1989; Smith, 1994; Guasti, 2003).

Furthermore, given the pervasiveness of *qualitative* elements in every cognitive dimension, and also the similar pervasiveness of notions like *continuity*, *integrity*, *cyclicity*, etc., we can assume that topology may be not merely sufficiently general to encompass a broad range of cognitive science subject-matters, but also that it will have the tools (*it is necessary*) to "play well" in these subject-matters, without imposing *alien* features (Smith, 1994).

Recent developments have demonstrated that it is possible to go beyond the merely metaphorical employment of topological concepts in cognitive science and neurosciences and to exploit the formal-ontological properties of these concepts for theoretical purposes in a "genuinely fruitful way"[1]. Thus, topology can serve as a theoretical basis for a unification of diverse types of facts.

If we consider, specifically the language faculty, I assume that, reduced to bare essentials, it is a cognitive system that stores information about sound and meaning. The basic units of the system are words (lexical items) stored in a Lexicon, each of which consists of a set of linguistic properties (*features*). Minimally, I assume that it could be an economical theory the one who tries to link - via *edges*[2] and *vertexes* - the interface levels that provide information to the conceptual-intentional systems and the sensor-motor systems, respectively (cf. Chomsky, 2004), also considering that it's widely accepted that syntactic relations are *local* (cf. Collins, 1997), often taking place between elements that are very "near by" (*linked*) within a phrase-marker. This is true, at a certain level of abstraction, even about *syntactic movement* phenomena,

[1] Cf. Sporns *et al.* 2004. "Organization, development and function of complex brain networks", in Trends in Cognitive Sciences 8: 9.

[2] The term *edge* is used in this work as "labeled linking object".

which turn out to be extremely constrained or *absorbed* by Merge (cf. Starke, 2001).

Assuming the generative paradigm as the point of departure for the theoretical foundation of my research, I have to say that I have followed - mainly - two axioms of "folk" minimalism:

The language faculty reflects a design that asks for simplicity and aims to minimize computation and to maximize resources.

Within the various elements of the computational process such as, for example representations, derivations, and so on, the goal in the Minimalist Program is *simplicity*.

Thus, minimalist economy seems to offer a simpler account of empirical facts: the linguistic module is designed in a way that necessarily avoids complexity. Norbert Hornstein (2000) describes it as follows:

"The idea is that locality conditions and well formedness filters are reflections of the fact that grammars are organized frugally to maximize resources. Short steps preclude long strides, derivations where fewer rules apply are preferred to those where more do, movement only applies when it must, expressions occur idly in grammatical representations (i.e. full interpretation holds)" (Hornstein, 2000: 18).

It's interesting to report that the idea of a cognitive module designed to maximize resources, and to avoid operations that are costly with respect to these resources (cf. also Fukui, 1993), is not unique to the linguistic module. Such ideas have also been raised with respect to other functions of the cognitive system as in, for example Kahneman's (1973) theory of visual perception, consisting of *perceptual units* and Biederman's (1987) theory of *geometric ions* (*geons*).

Recent researches have revealed general principles in the structural and functional organization of complex networks which are shared by various natural, social and technological systems, and are trying to codify the relationship between the structural substrate of *neuro-anatomy* and more dynamic functional and effective connectivity patterns that underlie human cognition (cf. Sporns *et al.* 2004).

Moreover, *complex networks*, in a range of disciplines from biology to physics, social sciences and informatics, have received significant attention in recent years (cf. Strogatz, 2001).

Networks are sets of nodes linked by connections, mathematically described as graphs (cf. Diestel, 2005). The nodes and connections may represent persons and their social relations, molecules and their interactions (cf. Barabasi and Albert, 1999), Web pages and hyperlinks (cf. Albert *et al.* 1999), or even the lexicon and morpho-syntax.

Sporns *et al.* (2004) argue that:

"What makes [such] networks complex is not only their size but also the interaction of architecture (the network's connection topology) and dynamics (the behavior of the individual network nodes), which gives rise to global states and 'emergent' behaviors" (Sporns *et al.* 2004: 418).

Nervous systems are complex networks for excellence, capable of generating and integrating information from multiple external and internal sources in real time. Within the neuro-anatomical substrate (structural connectivity), the non-linear dynamics of neurons and neuronal populations result in patterns of statistical dependencies (*functional connectivity*) and causal interactions (*effective connectivity*)[3], and human cognition is associated with rapidly changing and widely distributed neural activation patterns, which involve numerous cortical and sub-cortical regions activated in different combinations and contexts (cf. Varela *et al.* 2001; Sporns *et al.* 2004).

Barry Smith, an influential cognitivist and psychologist[4], in an interesting article from 1994, argues that "*the basic concepts of topology takes as its starting point the notion of transformation*". Obviously, this concept is shared by the generative Linguistics paradigm. Smith says:

"We note that we can *transform* a spatial body such as a sheet of rubber in various ways which do not involve cutting or tearing. We can invert it, stretch or compress it, move it, bend it, twist it, or otherwise knead it out of shape. Certain properties of the body will in general be invariant under such transformations - which is to say under transformations which are neutral as to shape, size, motion and orientation. The transformations in question can be defined also as being those which do not affect the possibility of our connecting two points on the surface or in the interior of the body by means of a continuous line" (Smith, 1994: 175).

Thus, I argue that is possible to use the term "topological spatial

[3] Cf. Turgut Tatlisumak and Marc Fisher eds. *Handbook of Experimental Neurology: Methods and Techniques in Animal Research*, Cambridge University Press 2006.

[4] Barry Smith has also collaborated often with the Italian philosopher Roberto Casati, who is extensively cited here, for his works with Achille Varzi, in paragraph 1.5.

properties" to refer, broadly, to those spatial properties of bodies and entities which are invariant under such transformations (transformations which do not affect the integrity of the entity - or other sort of spatial structure - with which we begin: this is the case of lexical items).

So, the property of being an (single, connected) entity is a topological spatial property, as also are certain properties relating to the possession of *holes* (more specifically: properties relating to the possession of tunnels and internal cavities[5]).

The property of being a collection of bodies and that of being an *undetached* part of a body, too, are topological spatial properties (Casati and Varzi, 1994). This concept of topological property can of course be generalized beyond the *spatial* case, such as *along* the *linearity* of language:

Linguistic expressions have items that enter into combinations; are discrete and, ideally, infinite.

The mechanism language works, in the chomskian paradigm, gives substance to the Cartesian intuition that human language is endlessly creative, and to the Von Humboldt's remark that it obtains unbounded expressiveness with finite means.

The class of phenomena structured by topological spatial properties is, indeed, wider than the class of phenomena to which, for example, Euclidean geometry, with its determinate Euclidean metric, can be applied. Thus topological spatial properties:

"are possessed also by mental images of spatially extended bodies. Topology is discernible also in the temporal realm: it has those properties of *temporal* structures which are invariant under transformations of (for example) stretching (slowing down, speeding up) and temporal translocation. Intervals of time, melodies, simple and complex events, actions and processes can be seen to possess topological properties in this temporal sense. The motion of a bouncing ball can be said to be topologically isomorphic to another, slower or faster, motion of, for example, a trout in a lake or a child on a pogo-stick" (Smith, 1994: 176).

The idea of forms (topological spatial properties) as a unitary and at the same time compositional phenomenon could perfectly fit a linguistic approach based on graph theory and topological formalisation (as we will see

[5] For an incredibly interesting survey on *holes* see Casati, Roberto and Achille Varzi. 1994. *Holes and Other Superficialities*, Cambridge, MA : MIT Press.

in the following chapters).

The developments among distant (but, not only metaphorically connected) fields (from genetics to informatics, from immunology to syntax[6]), as I have already pointed out, are part of a "wave" of contemporary thinking[7] and I think that their use in linguistics could lead to an interesting *driftage*: the whole work I have developed here could be seen as a "convoluted" provocation, but I think that is an incredibly amazing thing to search for a *key* that could be used as a *passepartout* for such disparate fields.

Therefore, in his seminal work *Structural Stability and Morphogenesis*, the mathematician René Thom applies topology (within his *catastrophe theory*) to a broad variety of domains in order to develop the outline of a general theory of models, with a special emphasis on qualitative models. His explorations cover a big list of issues: form and structural stability; catastrophes and morphogenetic fields; general geo-morphology and semantic models; the dynamic of forms: their mechanics, complexity, information, and significance; biology, embryology and the dynamics of living beings and cells; and, finally, language.

Thom's speculations regarding the application of qualitative models to linguistics and semantics provide some amazing insights into the *natural origins* of language and the processes of language usage. I will return, briefly, on Thom's theory in paragraph 1.5 (cf. also, Petitot, 1989).

Now let's turn out to consider some recent drifts (and *landing-places*) for the parallelism between biology and language: a parallelism that obviously entails an *evolutionary* issue.

1.2 A viral theory of (the evolution of) Language (Piattelli Palmarini & Uriagereka, 2004)

The cognitive science of language seeks to answer the questions of what the mechanisms underlying our use of language are, how these mechanisms

[6] See paragraph 1.2 for a survey on Piattelli-Palmarini, Massimo and Juan Uriagereka. 2004. "The immune syntax: the evolution of the language virus". In Lyle Jenkins (ed.), *Variation and universals in biolinguistics*, no. 62 in North Holland linguistic series: linguistic variations, Elsevier.

[7] At an "interface level" graph theory has been recently applied to develop a relationship between chemical structure and biological activity. For example the relationship of two graph invariants — molecular connectivity index and topochemical atomic molecular connectivity index, with anti-herpes simplex virus (HSV) activity has been investigated in S. Gupta, M. Singh and A. K. Madan. 2005. "Applications of graph theory: Relationship of molecular connectivity index and atomic molecular connectivity index with anti-HSV activity" Journal of Molecular Structure: THEOCHEM 571:1-3, Ps. 147-152.

arise in the individual, and, ideally, how they *arose* in the evolutionary history of our species. A few years ago, Marc Hauser, Noam Chomsky and Tecumseh Fitch published an influential paper, titled "The faculty of language" (Hauser *et al*., 2002). They ask which components of our linguistic abilities are uniquely human, and which components, or close analogues of those, can be found in other species (in a *broad* sense). In a talk during the Basque Country encounter with Noam Chomsky, held in 2006 in San Sebastian, Mark Hauser defines language:

"as *a mind-internal computational system designed for thought and often externalized in communication*. That is, language evolved for internal thought and planning and only later was co-opted for communication, so this sets up a dissociation between what we do with the internal computation as opposed to what the internal computation actually evolved *for*. We [Hauser, Chomsky and Fitch] defined the faculty of language in the broad sense (FLB) as including *all the mental processes that are both necessary and sufficient to support language*. The reason why we want to do it in that way is because there are numerous things internal to the mind that will be involved in language processing, but that need not be specific to language. For example, memory is involved in language processing, but it is not specific to language. So it's important to distinguish those features that are involved in the process of language computation from those that are specific to it. That's why we developed the idea of the faculty of language in the narrow sense (FLN), a faculty with two key components: 1) those mental processes that are unique to language, and 2) those that are unique to humans. Therefore, it sets out a comparative phylogenetic agenda in that we are looking both for what aspects are unique to humans, but also what aspects are unique to language as a faculty[8]".

Therefore, a very good summing-up of the observations made in that seminal article is the one made by Dennis Ott (2007):

"The picture that Hauser, Chomsky and Fitch offer is that of 'blind' recursive generation, coupled with interface components that transform the output of narrow syntax into representations encoding sound and meaning, and a range of modalities of performance, oral speech being one of them, that lie outside the narrow-syntactic system. suggesting that these performative components—conceptual-intentional and sensorimotor systems—are present in other species, such as higher primates—a conjecture that goes back to Descartes" (Ott, 2007: 78).

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[8] From M. Piattelli-Palmarini, J. Uriagereka and P. Salaburu Eds. (in press) *Of Minds and Language: The Basque Country Encounter with Noam Chomsky*, Oxford University Press.

I think that if the function of language (the *narrow* one) evolved only in humans, this suggests that its evolutionary history is incredibly short in biological terms. Indeed, there is evidence that language was born in humans about 100,000 to 40,000 years ago (Bickerton, 1990; Lass, 1997).

The recent paradigm shift in evolutionary biology, commonly labelled the *Evo-Devo* paradigm, has given wide credibility to claims of *saltational* emergence of a trait, triggered by some minimal mutation, or as a by-product of a functionally unrelated change, such as, for example, brain growth. For an introduction, one of the many works of divulgation written by S. J. Gould could be an interesting reading.

According to Anderson and Lightfoot (2003), which interestingly titled their book *The Language Organ – Language as Cognitive Physiology*, the theory of (universal) grammar must hold universally such that any person's grammar can be attained on the basis of naturally available *trigger* experiences.

> "The mature grammar must define an infinite number of expressions as well-formed, and for each of these it must specify at least the sound and the meaning. A description always involves these three items and they are closely related; changing a claim about one of the items usually involves changing claims about the other two. The grammar is one subcomponent of the mind, a mental organ which interacts with other cognitive capacities or organs. Like the grammar, each of the other organs is likely to develop in time and to have distinct initial and mature states" (Anderson and Lightfoot (2003: 45).

Modern physiology has discovered that the visual system recognizes triangles, circles or squares through the structure of the circuits that filter and recompose the retinal image (see the topographical model of Hubel and Wiesel, 1962). Certain nerve cells respond only to a straight line sloping downward from left to right within a specific, *narrow* range of orientations; other nerve cells to lines sloped in different directions. The range of angles that an individual neuron can register is set by a genetic program, but *experience is needed to fix the precise orientation specificity* (cf. the Nobel prize R. Sperry, 1961).

In Anderson and Lightfoot (2003) is depicted this interesting experiment:

> "In the mid-1960s David Hubel, Torsten Wiesel, and their colleagues devised an ingenious technique to identify how individual neurons in an animal's visual system react to specific patterns in the visual field (including horizontal and vertical lines, moving spots, and sharp angles). They found that particular nerve cells were set within a few hours of birth to react only to certain visual stimuli, and, furthermore,

that if a nerve cell is not stimulated within a few hours, it becomes totally inert in later life. In several experiments on newborn kittens, it was shown that if a kitten spent its first few days in a deprived optical environment (a tall cylinder painted only with vertical stripes), only the neurons stimulated by that environment remained active; all other optical neurons became inactive because the relevant synapses degenerated, and the kitten never learned to see horizontal lines or moving spots in the normal way" (Anderson and Lightfoot, 2003: 51. Cf. their work for other interesting interdisciplinary data).

We commonly see the process of language learning as a similarly selective process: parameters are provided by the genetic equipment, and relevant experience fixes those parameters (Piattelli-Palmarini and Uriagereka, 2004). Notice that a certain mature cognitive structure, in the sense of Anderson and Lightfoot, emerges at the expense of other possible structures, which are lost irretrievably as the inactive synapses degenerate.

Following Chomsky (2004), to a good approximation, the internal structure of the language organ is determined by *four* factors. The first factor is the *genetic endowment*, expressed in the initial state of the Language Faculty. The second factor is *external linguistic data*, which shapes the development of the language organ within *narrow boundaries* (cf. Guasti, 2003). The third factor comprises what is called "developmental constraints" in theoretical biology and general principles of biophysics. The fourth factor concerns the *embedding* of the Language Faculty within the mind, that is, the way it interfaces with other components (Ott, 2007).

Anyway, it is interesting to report here that Steven Pinker and Ray Jakendoff (2005) disagree in many respects (*dichotomies*) with the article by Hauser, Fitch and Chomsky. These include:

i) The Narrow/Broad dichotomy, which makes space only for completely novel capacities and for capacities taken intact from non-linguistic and non-human capacities, omitting capacities that may have been substantially modified in the course of human evolution;

ii) The utility/original-function dichotomy, which conceals the possibility of capacities that are adaptations for current use;

iii) The human/non-human dichotomy, which fails to distinguish similarity due to independently evolved analogous functions from similarity due to inheritance from a recent common ancestor;

> iv) the core/non-core and syntax/lexicon dichotomies, which omit the vast set of productive linguistic phenomena that cannot be analyzed in terms of narrow syntax, and which thus incorrectly isolate recursion as the only unique development in the evolution of language.

My personal opinion is that we acquire a productive system, a grammar, in accordance with the requirements of a *genotype*. We must assume that the linguistic genotype yields finite grammars, because they are represented in the finite *space* of the brain, but that they range over an infinity of possible sentences. This (*virtual or real*) genotype may act as a "parser" which interacts with the grammar to assign structures and meanings to incoming speech signals, and captures our capacity to understand spoken language in *real time*. I believe that the linguistic module contains abstract structures which are compositional (consisting of units made up of smaller units) and which fit a *narrow* range of possibilities.

At this point, speculations concerning language evolution become highly relevant for linguistic theory and I suppose that the proposal of Piattelli Palmarini and Uriagereka (2004), for which language has a *viral* origin, could be seen as more than a simple provocation.

Piattelli Palmarini and Uriagereka (henceforth: PP&U) argue that such a rapid transition (I mean, *from non-language to language*) cannot be easily accounted for in customary "adaptive" evolutionary terms and they propose that only a brain reorganization "of a drastic and sudden sort" could have given raise to such a state of affairs. This could be realistic simply assuming the *Evo-devo* paradigm cited above, but PP&U consider that two main facts suggest that this reorganization of human cognitive functions may have been "epidemic" in origin:

> i) Recent evolutionary accounts for the emergence of broad systems in organisms point in the direction of "horizontal" transmission of nucleic material, often of viral origin[9] (from viruses to parasites to transposable elements: the example *par excellence* is

[9] In situations of this sort, evolutionary rapidity is a consequence of boosting relevant numbers by having not individuals, but entire populations, carry relevantly mutated genetic material. Cf. *Microbiology and Immunology On-Line Textbook:* USC School of Medicine.

the origin of the Adaptive Immune System);

ii) When the formal properties behind context-sensitivity in grammar (for example as displayed in syntactic displacement) are studied in Minimalist terms, a surprising parallelism surfaces with the workings of the Adaptive Immunity.

The point of departure for PP&U is the consideration of the importance of "horizontal" transmission of mobile DNA sequences - called *transposable elements* - that are pervasive in the genomes of bacteria, plants and animals. These elements replicate fast and efficiently and it is common to find hundreds of thousands of copies of such elements in one single genome. Indeed, initial sequencing of the human genome revealed that as much as 45% of the total is constituted of DNA that originated from transposable elements[10].

Transposable elements can sometimes move "laterally" between species, a phenomenon known as *horizontal transfer*. Once these horizontal transfers of genetic material have successfully taken place, then ordinary "vertical" transmission perpetuates the new genome: for example, some researchers have suggested that the immune system of higher vertebrates is the product of the activity of a transposable element that was "domesticated" following horizontal transfer from a bacterium millions of years ago (cf. Hiom et al., 1998 cited in PP&U, 2004; and for a "broad spectrum" analysis the article of 1987, "Mitochondrial DNA and human evolution" by Cann *et al.*).

Then, the authors try to justify the assumption operated by Chomsky of the structural perfection of the "language organ", also considering the bizarre fact that creationists have used Chomsky's ideas as "evidence" against evolutionary theory.

PP&U search for biological counterparts that could be considered al least *quasi-perfect* and introduce the term "modular improvement". One example given of modular improvement is the cardiovascular system of vertebrates considered as a *fractal space filling network of branching tubes*, under the assumption that the energy dissipated by this transportation system is *minimized*.

It is an inspired account, in my opinion the one who consider the evolution of an entire mechanism (specifically chomskian Narrow Syntax) which

[10] Stable insertion of transposons, that evolve new coding and/or regulatory functions, sometimes occurs, with dramatic evolutionary consequences (Karp, 2004).

establishes one or more interfaces to be most likely *epigenetic* in nature: viral interactions provide the right level of complexity[11].

Furthermore, complex co-evolutions between viruses and hosts are known to have happened, with structural changes in the host, which in addition get transmitted to its offspring. For example the expression of captured genes encoding immuno-regulatory proteins is supposed to be one of the mechanisms used by viruses in their interaction with the host's immune system (cf. Hsu *et al.* 1990 cited in PP&U, 2004).

Along the lines of this biological substrate, PP&U proposal develops:

> "Suppose that, at some point, humans only had some primitive formal, perhaps a form of proto-language in the sense of Bickerton (1990) or maybe even a system unrelated to symbolic communication. Narrow Syntax in the sense that concerns most syntacticians would not have arisen yet. Then a major mind/brain reorganization would have taken place, which one hopes the detection of the morphological virus may be related to. The technical question is: supposing we have an organized elementary syntactic structure, and furthermore an alien element which in some sense does not belong, what can the host do in order to eliminate it? First of all, it must *detect* the intruder. This is no trivial task in a set of mechanisms which, by all accounts, has virtually no holistic characteristics. One possibility is for the host to detect the intruder on the basis of not being able to integrate it semantically. Next, there has to be some sort of "immune response", whereby the intruder is somehow eliminated. The issue here is "who" eliminates the virus, and "how". One must bear in mind that all of this has to be done with systemic resources. One of the few simple ways that a set of mechanisms of the assumed complexity would have of proceeding with the immunization task would be to *match* the virus element in categorial type". This is a kind of presupposed structure (non-terminal symbols, phrasal nodes) in phrase-structure grammars. It is as if a morphological "antigen" were detected and eliminated by a syntactic "antibody". As to how the elimination proceeds, one has to allow the set of mechanisms the ability to delete the virus matched by the antibody, under a strong version of the match: full categorial *identity*. In turn, if the host behaves as immune systems do, it should keep a *memory* of the process (after a single exposure to a virus, immune cells memorize the intruder and provide resistance for life)" (from Piattelli Palmarini and Urigereka 2004: 361-362).

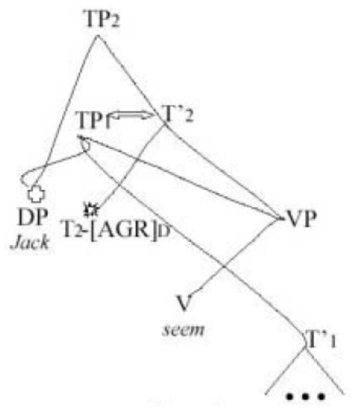
[11] Viruses are exquisitely species and tissue specific, they code for structural proteins and can infect an entire population, and importantly for our purposes, unlike bacteria or other parasites, they can integrate into a genome. Unlike maliciously built computational viruses, biological viruses don't have a purpose, thus may *a priori* result in a variety of consequences for an organism. Granted, the normal result is a more or less major disruption of the organism's functions or structure, due to the rapid multiplication of the infecting virus at the expenses of the host's own machinery, but this is not inevitable, and in principle a virus may sometimes be integrated stably, and inheritably, into the genome of its host (cf. Karp, 2004).

Presumably, then - if I understood correctly the assumptions made by the two authors - in the presence of a detected virus *v* of category X, the host will *systematically* respond with matching *antibody* category X, and the elimination of *v* under complete *featural* identity with the particular categorial values that X happens to exhibit or, otherwise the relevant host (derivation) would die (terminate). I report below an example of a *viral* linguistic derivation taken by PP&U (2004: 363):

(1-1) a. [_ [T-agr seem [[Jack] [to be …]]]][12]
target *source*
b. Virus (✶) detection: [T-[✶agr] [seem [[Jack] [to be …]]]]
c. Search for categorical match [T-[✶agr$_D$] [seem [[$_{DP}$Jack✚] [to be …]]]] with antibody (✚)
d. Eliminate virus under categorical identity [T-[✶agr$_D$] [seem [[$_{DP}$Jack✚] [to be …]]]]
D value = DP values
e. Systematize the sequence < b; c; d> as typical of the language

As a result of the transformational process, there is a demonstrable sense in which the formal object is more complex than it was prior to the "immunization", in that the basic "tree" relations are *warped*. This can be illustrated as in (2-1), taken from PP&U (2004: 363):

(2-1)



[12] In this instance the crucial feature in the target (of movement) are agreement features in Tense (T), and the source of the movement is *Jack*, which can appropriately check those uninterpretable features in terms of its own interpretable ones. In the process, the source element becomes accessible to the computation by way of Case valuation, which the target renders (Chomsky, 1995).

So, it is possible to argue that the *warped* object resulting from associating the *antibody* DP to the T with a *viral* feature - which happens to be of the Determiner sort (for example agreement in person/number) - creates new local relations (Collins, 1997).

In particular, the viral antigen-antibody relation establishes a "chain". For instance, TP_1 in (2-1) (the mother of the *Jack* node) establishes the context for the lower link in the chain, while the T'_2 in the example (the mother of the T_2 node hosting the antigen) establishes the context for the higher link in the chain. The chain linking the two relevant sites for the immunization is {{*Jack*, T'_2 }, {*Jack*, TP_1}}, or {T'_2, TP_1} factoring out *Jack*.

For PP&U a syntactic *chain* is analogous to secondary structuring in nucleic acids, that is, the establishment (through something like *pseudo-knots,* which are pairs of stem-loop elements in which part of one stem resides within the loop of the other) of relations between bases further apart in the linear sequence: relations other than the most elementary pairings which primary structure yields. Just as RNA secondary structures have numerous consequences (through the ability of information sharing of a sort which, without the *pseudo-knot*, would be too long-distance to be viable) so too chains have consequences (see paragraph 1.3 and fig. 1-1).

Thus, in the PP&U view, the complex object in (2-1) is simply a rearrangement of more elementary lexical features, nothing more holistic than that.

The above result is definitely topological:

> "After the immunization takes place, a (new) linguistic topology emerges, and the result lends itself to otherwise impossible interpretations" (Piattelli Palmarini and Uriagereka, 2004: 365).

I realize that PP&U conjecture is essentially metaphorical. Nonetheless, I think this metaphor is productive and worth pursuing to its several interesting consequences. Indeed, there are reasons (hints) to believe that it may be more than just a metaphor. The next two paragraphs should be explicatory.

1.3 The language of genes (David B. Searls, 2002)

In the 1980s, several researchers began to follow various threads of Chomsky's legacy in applying linguistic methods to molecular biology. The main results included the fundamental observation that formal representations could be applied to biological sequences — the extension of linguistic formalisms in new, biologically inspired directions — and the demonstration of "the utility of grammars in capturing not only informational but also structural aspects of macromolecules" (cf. Searls, 1992).

David B. Searls in an interesting article published on Nature in 2002 demonstrated in which way is possible to apply linguistics to the structure of nucleic acids. In brief, Searls showed that a folded RNA secondary structure entails pairing between nucleotide bases that are at a distance from each other in the primary sequence, establishing (in some way) those relationships that in linguistics are called *dependencies*.

The most basic secondary-structure element is the *stem-loop*[13], in which the stem creates a succession of *nested* dependencies that can be captured in an idealized form by the following context-free base-pairing grammar, as reported in (Searls 2002: 211) (see Chapter two for a survey on Chomsky's hierarchy).

(3-1) [$S \rightarrow gSc;\ S \rightarrow cSg;\ S \rightarrow aSu;\ S \rightarrow uSa;\ S \rightarrow \varepsilon$]

(Where the ε in the last rule indicates that an *S* is simply erased.)

For Searls this grammar affords any and every derivation of "hairpin" sequences of a form such as the following:

(4-1) $S \rightarrow gSc \rightarrow gaSuc \rightarrow gauSauc \rightarrow gaucgaSucgauc \rightarrow gaucgaucgauc$

Derivations from this grammar grow outward from the central *S*, creating the nested dependencies of the stem (Fig. 1-1a), analogous to such phenomena as nested relative clauses in natural language.

We have to say that in a realistic stem-loop, the derivation would terminate in an unpaired loop of at least several bases and might also contain, for example, non-Watson–Crick base pairs. But such features are easily added to the grammar without affecting the fundamental result that any language consisting of RNA sequences that fold into these basic structures requires context-free expression.

[13] The structure is also known as a hairpin or hairpin loop. It occurs when two regions of the same molecule, usually palindromic in nucleotide sequence, base-pair to form a double helix that ends in an unpaired loop. The resulting lollipop-shaped structure is a key building block of many RNA secondary structures (cf. Watson JD, Baker TA, Bell SP, Gann A, Levine M, Losick R. (2004). *Molecular Biology of the Gene*. 5th ed. CSHL Press)

Then Searls note that, in addition to stem-loop structures, arbitrarily branched folded structures may be captured by simply adding to the grammar above a rule $S \rightarrow SS$, whose application creates bifurcations in the derivation tree (Fig. 1-1b).

The base-pairing dependencies remain non-crossing, although more complicated. The resulting grammar is formally ambiguous, meaning that there are guaranteed to be sequences in the language for which more than one derivation tree is possible.

Thus, the string *gaucgaucgauc* can be derived as a single hairpin or as a branched structure (Fig. 1-1a,b). This linguistic property of ambiguity, reflected in natural languages in sentences that can be syntactically parsed in more than one way (for example, "*She saw the man with the telescope*"), directly models the biological phenomenon of *alternative* secondary structure.

Furthermore, finding that the language of RNA is at least context-free has mathematical and computational consequences, for example, for the nature and inherent performance bounds of any algorithm dealing with secondary structure[14] (Knudsen and Hein, 1999).

These consequences show the importance of characterizing linguistic domains in the common terminology and methodology of formal language theory, so as to connect them immediately to the wealth of tools and understanding already available[15].

In the light of these practical consequences of linguistic complexity[16] (cf. Shieber, 1985), a significant finding is that there exist phenomena in RNA that in fact raise the language even beyond context-free.

The most obvious of these are so-called non-orthodox secondary structures, such as *pseudoknots* (Fig. 1-1c). This configuration induces cross-serial dependencies in the resulting base pairings, requiring context-sensitive expression

Searls argue that, given this further promotion in the Chomsky hierarchy,

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[14] For instance, the fast, regular expression search tools used commonly in bioinformatics (such as those in the popular Perl scripting language) are ruled out, as in their standard form they specify only regular languages (Knudsen and Hein, 1999).

[15] For this reason, from early nineties bioinformatics textbooks have devoted whole chapters to the relationship of biological sequences to the Chomsky's hierarchy.

[16] Natural languages seem to be beyond context-free as well, based on linguistic phenomena entailing cross-serial dependencies, although in both domains such phenomena seem to be less common than nested dependencies. Thus, by one measure at least, nucleic acids may be said to be at about the same level of linguistic complexity as natural human languages. For some observations on this issue see Shieber, S. 1985. "Evidence against the context-freeness of natural language". *Linguist. Phil.* **8,** 333–343,

the need to encompass pseudoknots within secondary-structure recognition and prediction programs has significantly complicated algorithm design. Another non-context-free phenomenon that occurs in RNA is a consequence of alternative secondary structure, such as that seen in *bacterial attenuators*[17], which are regulatory elements that depend on switching between conformations in nascent mRNA molecules (Fig. 1d).

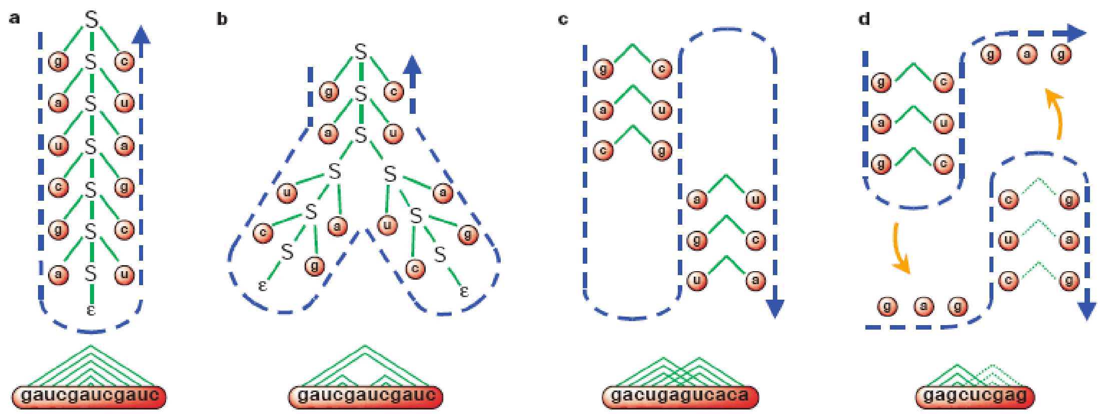

fig. 1-1 (taken from Searls, 2002: 212)

For any grammar required to simultaneously represent both conformations, these mutually exclusive options create overlapping (and thus cross-serial) dependencies in the alternate base-pairing schemes, as already showed by Searls in 1992, ten years before is seminal work published in Nature.

I think that in Searls (2002) the most crucial point is that genes do convey information, and this information is organized in a hierarchical structure whose features are ordered, constrained and related in a manner analogous to the syntactic structure of sentences in a natural language. Thus, it is not surprising for me at all that a number of themes, both explicit and implicit, have found their way from (computational) linguistics to (computational) biology.

One implicit theme is a convergence between organizational schemes in the two fields. Language processing is often conceived as proceeding from:

i) the *lexical level*, at which individual words from a linear input stream (of, for example, phonemes or characters) are recognized and characterized to:

ii) the *syntactic level*, at which words are grouped and

[17] Cf. Neri G and Genuardi M (eds.). 2006. *Genetica Umana e Medica*, Masson, Milano

related hierarchically according to grammar rules to form a structural description to

iii) the *semantic level*, at which some representation of meaning is assigned to the resulting structure, derived from that of its individual lexical elements and finally to

iv) the *pragmatic level*, at which language is viewed in a larger context encompassing the roles and interrelationships of in an overall discourse.

In particular, the distinction between syntax and semantics (needless to come back to Chomsky's "*Colourless green ideas sleep furiously*") is pertinent to biology and I think it's meaningful to end this paragraph citing what Searls (2002: 215) says about this parallelism:

"Consider two types of sequence: a string of words, and a segment of a genome. A parsing step may be seen as determining whether the words form a grammatical sentence, or, notionally, whether the genomic sequence will support the production of a polypeptide according to rules implicit in the transcriptional and translational machinery of the cell; in both cases the processes are mechanical, in fact largely processive. Then, an interpretative step determines whether the resulting sentence is meaningful, according to laws of logic and experience, or whether the polypeptide will fold into a compact core and orient its side chains so as to do useful work, a process governed by laws of thermodynamics and biochemistry. Mutated genes that are expressed but do not allow for a functional fold may be said to pass the first test but not the second".

1.4 The gene of languages: FOXP2

In 2001 Lai *et al*. have found a gene, FOXP2, which seems to be involved in speech. This regulating gene, located on chromosome 7[18], was discovered while studying a family most of whose members had troubles, at least,

[18] Note that The FOXP2 protein sequence is highly conserved. Similar FOXP2 proteins can be found in songbirds, fish, and reptiles such as alligators (cf. Enard *et al.* 2002). Aside from a polyglutamine tract, human FOXP2 differs from chimp FOXP2 by only two amino acids, mouse FOXP2 by only 3 amino acids, and zebra finch FOXP2 by only 7 amino acids (cf Lai *et al.* 2001). Some researchers have speculated that the two amino acid differences between chimps and humans was the thing that led to the evolution of language in humans. (cf. Lai *et al*. 2001) Others, however, have been unable to find a clear association between species with learned vocalizations and similar mutations in FOXP2. (Enard *et al.* 2002) Both human mutations occur in an exon with no known function.

controlling their lips and tongue and forming words[19]. Possibly, FOXP2 is responsible for the "linguistic big bang".

In particular, the family in question presents a mutation in the gene which disrupts the DNA-binding area of the protein it specifies. Even more recently, Enard *et al*. (2002) studied FOXP2's evolutionary history by comparing versions of the gene in various primates and mice. FOXP2 has remained essentially unaltered during mammalian evolution, but it changed in humans (affecting at two sites the structure of its protein) after the *hominid* line of descent had split off from the closely related *chimpanzee* one. The changes in the gene (which alter the protein shape and its functional role) are universal in human populations.

Enard *et al*. speculate that the changes affected speech articulation, and by measuring the reduced diversity in the DNA section corresponding to the gene (the result of its sweeping through the population) they estimate that the human version of the gene emerged only 120,000 years ago[20.]

Those results are very consistent with others pertaining to the timing of geographical dispersion, offered by comparative genetic studies carried ever since the already cited here Cann *et al*. (1987), both on mitochondrial DNA and the Y chromosome of people from diverse ethnic backgrounds. This evidence indicates that the world's population can be traced back to a family tree rooted in sub-Saharan Africa less than 200,000 years ago, and a branch leading into the rest of the world somewhere within the last 100,000 years (perhaps even 50,000 or less (cf. Lass, 1997)).

FOXP2 is a member of the large FOX family of transcription factors[21]. Information from known human mutations and mouse studies suggests that FOXP2 regulates genes involved in the development of tissues such as brain,

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[19] The inspection of the family (known as the "KE family") revealed the disorder to be autosomal dominant. A scan was performed of the genome of the affected and some of the unaffected family members. This initial scan limited the affected region to a spot on chromosome 7, which the team called "SPCH1". Sequencing of this region was done with the aid of bacterial artificial chromosome clones. At this point, another individual was located who had a similar disorder but was unrelated to the family. The genome of this individual was mapped and it was discovered that there was a "break" in chromosome 7. Further investigation discovered a point mutation in this chromosome (cf. Lai *et al*, 2001).

[20] A recent extraction of DNA from Neanderthal bones indicates that Neanderthals had the same version (allele) of the FOXP2 gene that is known to play a role in human language (cf. Paabo *et al.* 2007).

[21] Briefly, a transcription factor is a protein that binds to the promoter region of other genes and facilitates their transcription from DNA to RNA. In other words, in the presence of the transcription factor a gene makes protein; in its absence it does not. (Cf. Neri and Genuardi, 2006)

lung, and gut. The exact identity of the genes FOXP2 regulates is still not known, however, but several cases of developmental verbal *dyspraxia* in humans have been linked to mutations in the FOXP2 gene.

As already mentioned, individuals have little or no cognitive handicaps but are unable to correctly perform the coordinated movements required for speech. The analysis of these individuals performing silent verb generation and spoken word repetition tasks showed a sort of underactivation of Broca's area and the putamen, brain centers known to be involved in language tasks[22]. Scientists have also looked for associations between FOXP2 and autism but so far no evidence has been found (cf. Enard *et al.* 2002).

Therefore, we have to say that from the beginning, there has been a range of views in the professional scientific community with regard to whether the gene in question is a "language" or a "grammar" specific gene. Those disagreements continue in a somewhat abated form today. Let's resume the whole story.

In 1995, Vargha-Khadem *et al*, published a paper investigating the *phenotype* (remember that the discover of the FOXP2 gene is from 2001) of the family that share the disorder and showing quite clearly that it is not grammar or speech specific. They tested affected and unaffected family members and concluded that the disorder had the following characteristics: defects in processing words according to grammatical rules; understanding of more complex sentence structure such as sentences with embedded relative clauses; inability to form intelligible speech; defects in the ability to move the mouth and face not associated with speaking (relative immobility of the lower face and mouth, particularly the upper lip).

Then, in 1998 Vargha-Khadem *et al.* looked at functional and structural abnormalities in the brains of the affected subjects. Basically they found several structural and functional (degrees of activity - shown by PET scan) brain abnormalities in the affected family members. The most significant abnormality was a bilateral reduction in the size of caudate nucleus (a component of the basal ganglia[23]) coupled with abnormal high activity in the left caudate nucleus during speech tasks. Broca's area, important for speech production, was also smaller and over-activated during speech production in affected subjects.

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[22] For an interesting attempt to find a relation between Broca's Area and Universal Grammar, see the hypothesis in Moro et al. 2003.

[23] The caudate nucleus is implicated in motor co-ordination and also processes information that is being sent from other areas of the brain to the frontal lobe (Cf. MIT Encyclopedia of Cognitive Sciences, 1998).

Then in 2001, Lai *et al*. published the paper announcing that they had identified the precise gene that has a mutation in affected members of the target family and the story is known.

It is interesting to report that Steven Pinker's view (*from a newspaper interview*) about FOXP2 is that the fixed human-specific mutations in the gene might enable fine oro-facial movements and so trigger the development of language and PP&U think that FOXP2 gave humans a significantly improved "phonotactic kit", hence a massively expanded phonetic vocabular that allowed a "proto-language" for elementary grounded messages, involving indexicals (or names) combined with immediate locations, or even salient characteristics. Chomsky has ignored FOXP2 at all.

In my opinion, there is broad evidence that the linguistic impairments associated with a mutation of the FOXP2 gene are not simply the result of a fundamental deficit in *motor* control:

i) the impairments include difficulties in comprehension;

ii) brain imaging of affected individuals indicates functional abnormalities in language-related cortical and basal/ganglia regions, demonstrating that the problems extend beyond the *motor system* (cf. Lai et al., 2001).

Futhermore PP&U (2004) suggest that the capacity of a child to acquire effortlessly, very early - prior to the third year, and with only quite marginal rates of error - the elaborate morphology of a mother language (Pinker, 2000) may be under the control of very few specific genes, perhaps only one. Such ease and precocity is not uniform across linguistic capacities.

The acquisition of the morpho-lexical system is also mastered early on. *From 1 year of age until about age 6, the child acquires, on average, one new item for every waking hour*. Biological evidence here is mostly indirect, from specific pathologies (anomia and category-specific semantic deficits (since McCarthy and Warrington, 1988)), and from the extreme slowness with which other primate species learn a handful of new words, even under intensive training. For PP&U it seems plausible, nonetheless, to attribute this capacity to a genetic predisposition, possibly under the governance of the same genes as morphology:

"Far from being a lengthy process of trial-and-error, propelled by inductive guessing, language acquisition consists of a (possibly random) cascade of discrete selections, as the child's linguistic system stably "locks onto" the values of each parameter (Piatteli Palmarini and Uriagereka, 2004: 358)".

The relevant fragments of linguistic input have been, revealingly, called "triggers" (Fodor, 1998; Lightfoot, 1999). Linguistic theory is constrained to offer only hypotheses that, in principle, satisfy the *learnability* requirement.

Anyway, it would be interesting to develop such issues in further researches.

1.5 Cognitive nodes and topology among human sciences *a brief historical excursus with particular regard to Philosophy of Language*

I briefly introduce in this final section of the chapter some interesting "network theories" linked to Human Sciences, with particular regard to Philosophy of Language, developed through the last ten centuries: from the "linear field" of Raymundus Lullus, to the "regular surface" (as a sort of generative mechanism of infinite space filling the system) of Bruno; from the Gestalt's approach to language to the "frames" of Fillmore. This section has been developed following the stimulating traces left by Wildgen (1994; 1998). There exist, in fact, very different perspectives concerning the geometries of lexical fields, but there is a *linear* array of ideas, concepts and words, the extremes of which may be *linked* together. The proposal I will develop in the following sections will be strictly *linear* in nature, but has been inspired by a relevant set of *geometrical* ideas.

1.5.1 Linear fields and circles, regular surfaces and the spatialization of intentional concepts: from Lullus to Bruno to Leibniz.

The first systematic "spatial" organization of lexical items (or their concepts) was put forward by Raymundus Lullus (1232-1314), a Spanish philosopher sometimes considered a pioneer of computation theory. All conceptual systems of his most important work, *Ars Magna*, are arranged in a linear order with (normally) nine segments. Since the extremes of this segments are joined, we have a circular field. Every concept has two neighbours, and by adding specific geometrical figures (triangles, squares, etc.) it is possible to link three or more concepts to create a sub-network. Then, the concepts of an area of knowledge may be organized into a set of such nine "fields".

On top of all the more specific conceptual fields (arrays of nine concepts), stands a universal field, which contains those qualities of God that are at the origin of all further entities and their concepts. This semantic system has an ontological and metaphysical foundation in the tradition of Aristotelian and medieval logic (figure 2-1).

Fig. 2-1. Lullus' Ars Magna

The idea that concepts/words form linear arrays, that the extremes may be linked together, and that a hierarchy of such arrays exists, is a sort of first realization of "field-semantics" (cf. Wildgen, 1998).

Anyway, the interesting thing here, is that Lullus did not stop at the static idea of a (circular) field of concepts: he proposed a combinatory mechanism which may have been motivated by the "machinery" of medieval syllogistics, but which contained a new mathematical impulse which allowed the later development of computing machines by Leibniz, Pascal, and others (cf. Wildgen, 1994).

Leibniz gave to the Lullus' idea the name *Ars Combinatoria*, by which it is now often known. It's interesting to notice that some computer scientists have adopted Lullus as a sort of founding father, claiming that his system of logic was the beginning of information science.

This method was an early attempt to use logical means to produce knowledge. Lullus hoped to show that Christian doctrines could be obtained artificially from a fixed set of preliminary ideas. For example, one of the *tables* listed the attributes of God: goodness, greatness, eternity, power, wisdom, will, virtue, truth and glory. Lullus knew that all believers in the monotheistic religions - whether Jews, Muslims or Christians - would agree with these attributes, giving him a firm platform from which to argue. A hierarchy of linear (and circular) fields, and a combinatorial dynamics on it, already constitute a powerful theoretical instrument for organizing the universe of concepts, and represent a sort of gate to the lexicon[24].

In the late sixteenth century, Giordano Bruno (1548-1600) began to elaborate the Lullian system, approaching to a new system of conceptual organization based on the analogy between the universe and the mind. He replaced Lullus's closed linear field with a regular, *bidimensional* pattern extending to infinity. Bruno's view of the fundamental workings of language based on his studies of ancient languages, approaches that of contemporary semiotics: "Images do not receive their names from the explanations of the things they signify, but rather from the condition of those things that do the signifying[25]". A view which was repeated by Fernand de Saussure nearly 300 years later in the 1890's with his idea that a word is composed of two parts: the "signified" and the "signifier", and is at the foundation of contemporary linguistics.

From a mathematical point of view, Lullus's field is a circular segment divided into nine sub-segments. Wolgang Wildgen notes that:

> "If instead of linear segments the basic unit is a regular surface, we may consider either the filling of an (infinite) area by circular surfaces (spheres), or its filling by regular surfaces (polygons) or bodies (polyhedra). The corresponding mathematical problem is that of an (optimal) package of circles/spheres or polygons/polyhedra" (Wildgen 1998: 216).

Bruno decided exactly that the filling of a surface by squares is most adequate: his semantic universe is constructed on the basis of a square grid. Note that Bruno's system as a sort of internal dynamic that concerns what now we call "the fillers of the memory pattern[26]". Every word in a pattern may be replaced by its metaphor or its metonym. Thus, for Bruno, a text

[24] Studies upon Lullus of every variety appear now throughout the world, the majority of which are reviewed in the bibliographical bulletin of the journal *Studia Lulliana*, available on-line.

[25] Giordano Bruno, *On the Composition of Images, Signs & Ideas*, (p. 31), ed. by Higgins, Dick New York: Willis, Locker & Owens, on-line available.

[26] Cf. McElree, Brian, Foraker Stephani and Dyer Lisbeth. 2003. "Memory structures that subserve sentence comprehension" in Journal of Memory and Language 48, 1 : 67-91.

which was first generated along the lines of basic meanings associated with the terms filled into the system can produce a totally different text or text interpretation by using a set of metaphorical and metonymical processes.

Some authors think that the consequences of Bruno's parallel work on cosmology and artificial memory are a new model of semantic fields which was so radical in its time that the first followers (although ignorant of this tradition) are the Von-Neumann automata (cf. Sporns and Alexander, 2002) and the neural net systems of the late 1980s (cf. Wildgen 1998: 237).

The tradition of Lullus and Bruno was still alive when Leibniz (1646-1716) designed his "*De Synthesi et Analysi universali seu Arte inveniendi et judicandi*". Leibniz' solution is an arithmetic one and can be interpreted as a precursor of *feature-semantics*[27]. It associates cognitively primitive (i.e. non-definable) concepts with prime numbers. All definable concepts correspond to non-prime numbers, which can be decomposed into prime numbers. Leibniz eliminates (as Lullus did) the basic distinction between subject and predicate, and practically considers only two levels: primitive and (by definition) composite concepts.

Then, Leibniz sketches a constructive device, which generalizes the methods of Euclid and applies them to conceptual systems[28]. The transition from the arithmetical to the geometrical characteristic corresponds to the transition between possible (conceivable) worlds, as pure intention, to the real world, to the spatialization and temporization of intentional concepts. Central notions are geometrical congruence and the intersection of geometrical figures[29].

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[27] A rough presentation: a semantic feature is a notational method which can be used to express the existence or non-existence of semantic properties by using plus and minus signs.

(i)
Man is [+HUMAN], [+MALE], [+ADULT]
Woman is [+HUMAN], [-MALE], [+ADULT]
Boy is [+HUMAN], [+MALE], [-ADULT]
Girl is [+HUMAN], [-MALE], [-ADULT]

Intersecting semantic classes share the same features. Some features need not be specifically mentioned as their presence or absence is obvious from another feature: This is a redundancy rule.

[28] For a detailed explanation see Rutherford, D., 1998. *Leibniz and the Rational Order of Nature*. Cambridge University Press.

[29] Note that Leibniz was the first to use the term "analysis situs" later used in the 19th century to refer to what is now known as *topology*. There are two takes on this situation. On the one hand, Mates (1986: 240), citing a 1954 paper in German by Freudenthal, argues:

"Although for [Leibniz] the situs of a sequence of points is completely determined by the distance between them and is altered if those distances are altered, his admirer Euler, in the

In brief, Leibniz demonstrates only how the simplest notions like space, point, line, plane, circle, position in space are constructed. This type of conceptual characteristic has the merit that all entities defined can be constructed and Leibniz imagines how his system if elaborated can be used to describe plants and animals and to invent machines. The geometrical characteristic would allow man to do this with symbolic techniques in his imagination without the help of concrete figures and models[30].

1.5.2 Gestalt theory and the topological psychology of Kurt Lewin

At the origin of Gestalt theory stands philosophy and psychology, which were not yet institutionally separated in Germany in early 1900s. In the various schools of Gestalt psychology (Berlin, Graz, Leipzig) different aspects were foregrounded: psychophysiological aspects in Berlin (e.g., Wertheimer, Koffka, Köhler, Lewin), intellectual forces as Gestalt-foundation in Graz (e.g.,

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famous 1736 paper solving the Königsberg Bridge Problem and its generalizations, used the term geometria situs in such a sense that the situs remains unchanged under topological deformations. He mistakenly credits Leibniz with originating this concept. ...it is sometimes not realized that Leibniz used the term in an entirely different sense and hence can hardly be considered the founder of that part of mathematics."

But Hirano (1997) argues differently, quoting Mandelbrot (1977: 419):

"...To sample Leibniz' scientific works is a sobering experience. Next to calculus, and to other thoughts that have been carried out to completion, the number and variety of premonitory thrusts is overwhelming. We saw examples in 'packing,'. A "topological" interest for Leibniz is further reinforced by finding that for one moment its hero attached importance to geometric scaling. In "Euclidis Prota"..., which is an attempt to tighten Euclid's axioms, he states,...: 'I have diverse definitions for the straight line. The straight line is a curve, any part of which is similar to the whole, and it alone has this property, not only among curves but among sets.' This claim can be proved today."

Thus the fractal geometry promoted by Mandelbrot drew on Leibniz's notions of self-similarity and the principle of continuity: *natura non facit saltus*.
We also see that when Leibniz wrote, in a metaphysical vein, that "*the straight line is a curve, any part of which is similar to the whole*..." he was anticipating topology by more than two centuries (cf. wikipedia.org-> Leibniz).

[30] Leibniz' critique of image-like models can be generalized to all too specific and ad hoc pictorial descriptions. In an interesting paper that trace the linguistic influences of Leibniz, Wolfgang Wildgen, who says:

"A strategy already condammed by Leibniz 300 years ago is systematically tried by cognitive semantics which work with ad hoc figures and with pictures which have no theoretical status. Semantics of this type will soon accumulate a chaotic universe of ad hoc figures and will loose the capacity to find general and stable regularities which is a central aim of any scientific enterprise. Thus Leibniz geometrical characteristic is a kind of deconstruction of cognitive semantics in the style of Lakoff". (Widgen 1998; p. 224)

Meinong, Benussi), emotional and symbolic aspects in Leipzig (e.g., Cornelius, Bühler) (cf. Casati and Varzi, 1999).

Gestalt theory, in the most general terms, is a theory of mind and brain that proposes that the operational principle of the brain is holistic, parallel, and analog, with self-organizing tendencies; or, that the whole is greater than the sum of its parts. The classic Gestalt example is a soap bubble, whose spherical shape is not defined by a rigid template, or a mathematical formula, but rather it emerges spontaneously by the parallel action of surface tension acting at all points in the surface simultaneously. A good summing up is the one made by Casati and Varzi:

> "Gestalt theorists emphasise the figure-ground articulation of perceived configurations. Some portions of a perceived scene, due to their intrinsic wholeness, are perceived as figure, and are delineated against a background which is perceived as completing itself behind the figure. Now, the visual boundary that separates figure from ground is "oriented": it belongs to the figure and not to the ground[31]".

For linguistics issues, the most prominent figure of Gestalt is probably Kurt Lewin (1890-1947). As early as 1912 Kurt Lewin foresaw that a scientific psychology would have to make use of "topology" and of "the dynamics which could be conceived in a topological structure" (cf. Lewin 1969: 9).

Many of Lewin's ideas recall principles of "force dynamics" worked out in greater sophistication in the linguistic sphere by Talmy (1988), and Talmy, along with Petitot (1989) and others, tried to demonstrate the importance of topology for the understanding of a variety of different sorts of linguistic structuring (cf. paragraph 1.5.4).

As Talmy notes, the conceptual structuring effected by language is illustrated most easily in the case of prepositions. A preposition such as' *in* is magnitude neutral (in a thimble, in a volcano), shape neutral (in a well, in a trench), closure-neutral (in a bowl, in a ball); it is not however discontinuity neutral (in a bell-jar, in a bird cage). Work on verb-aspect and the mass-count distinction, too, has profited from a topological orientation in the paradigm of Cognitive Linguistics (cf. paragraph 1.5.4).

Lewin's central idea was that of a "psychological life-space" (*psychologischer Lebensraum*): life-space is constituted by the individual and a situation relevant for the individual at a given moment. The life-space of an individual has two aspects: every partial domain of an individual's life-space

[31] From Casati, Roberto, and Varzi, Achille., 1999, *Parts and Places*: *The Structures of Spatial Representation*. Cambridge, Mass.: MIT Press.

corresponds to a "psycho-domain", containing the person, structures of the life-space specifically relevant for the person (individual situations) and structures of the life-space which are constituted independently from the person (standard situations)[32] and psychic "locomotion", such as paths in the life-space with preferred routes, barriers and obstacles.

So, language has a major function in the Lewin framework*: it transfers internal states of the person to his/her environment*. Language enables a type of indirect locomotion in psychic space: for example, surrogate locomotion as in the speech act of ordering or in social coordination via language, change of social and personal relations and cognitive influence, which creates new possibilities of psychic locomotion via learning.

From a *narrow* psychological point of view, Lewin begins with the opposition thing (intuitively: a *closed connected* unity) and region (intuitively: a *space within* which things are free to move). As Lewin points out, what is a thing from one psychological perspective may be a region from another:

> "A hut in the mountain has the character of a thing as long as one is trying to reach it from a distance. As soon as one goes in, it serves as a region in which one can move about." (Lewin, 1969: 116)

He defines the notion of a boundary zone z between two disconnected but proximate regions m and n, as the region, foreign to m and n, which has to be crossed in passing from one to the other. The whole $m + n + z$ is then connected in the topological sense. (Lewin 1936: 121)

The concept of a *barrier* he defines as a boundary zone which offers resistance to passage of things between one region and another (Smith, 1994).

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[32] For Lewin, the development of a child or an adult may be described as a change in life-space. The life-space of a child alters as soon as it learns to grasp, to control, to walk, to speak, and so on. A prisoner has a dramatically reduced life-space and some situations may contain attractors (cf. emotional attractors, sympathy, love, etc.) or repellers (situations of frustration, anger), which provoke reactions of escape.

Thus far we have considered the person to be an integral component of a life-space. But persons may themselves be regarded as a topological field with an inner area (intrapersonal domain), a periphery of this domain, and a sensor-motorical domain, which lies between the person and his/her context (the situation).

The topological psychology of Lewin was later elaborated by Fritz Heider in his "attributional psychology". Heider strengthened the relation between 'life span' categories and semantic categories, for example, perceptual, experimental, affecting, causing, evaluation, part-whole relations (possessive), can, trying, wanting, etc. (cf. Heider, 1958). Thus, the psychic and the symbolic world have the structure of a field, and topological and dynamic (vectorial) notions from contemporary mathematics are used in Heider (1958) to specify these fields.

Such resistance may be *asymmetric*; thus it may be greater in one dimension than in the opposite direction.

Barriers effect the degree of communication between one region and another, or in other words the degree of influence of the state of one region on that of another region. Hence the notion of degree of influence, too, need not be *symmetric* (Smith, 1994). For example, the fact that *A* is in a certain degree of communication with *B* does not imply that *B* is in equally close communication with *A*.

In Lewin's paradigm two regions *A* and *B* are said to be parts of a dynamically connected region if a change of state of *A* results in a change of state of *B*. The notion of dynamic connectedness, too, is by what was said earlier a matter of degree. In fact we can distinguish a hierarchy of degrees of inter-linkage between regions, and here Lewin echoes discussions in the Gestalt-theoretical literature of the notions of "strong" and "weak" Gestalten (1969: 173).

A *strong* Gestalt may be defined as a complex with a high degree of dynamic connectedness between its parts (examples given: an organism, an electromagnetic field).

A *weak* Gestalt, for example a chess-club, has a lesser but still non-zero dynamic connectedness between its parts, while a purely summative whole (an *Und-Verbindung* in Gestalt terminology) is such that its separate units manifest a zero degree of *dynamic connectedness*[33] (Smith, 1994).

We have introduced the basic concepts of Lewin's topological psychology in a rather general way, abstaining from any specific applications to psychological matters. It will extend too much the scope of our discussion; it is interesting to notice that Lewin's critics, however, rightly drew attention to a certain crucial *shortfall* in his use of mathematical notions in his writings. As was correctly pointed out by his critics, Lewin rarely makes the mathematical theory of notions such as connectedness, boundary, separateness, and so on, do any substantial work within the framework of his investigations[34].

Anyway certain aspects of Lewin's generalizations of standard topology have since shown themselves to be highly fruitful if applied to a linguistic field. In my opinion, these generalizations include:

[33] Interestingly, in the light of our discussions, the notions central to Gestalt theory can be defined not merely on the basis of the notion of dynamic connectedness, but also in terms of structure-preserving transformations.

[34] This criticism was put forward in an influential article by London (1944), an article which did much to thwart the further development of topological psychology (or of a topologically founded cognitive science) as Lewin had conceived it.

i) the recognition that it is possible to construct topology on a non-atomistic, *mereological* (cf. Casati and Varzi, 1999) basis which works in terms of wholes (regions) as well as parts;

ii) the systematic employment of the notion of *asymmetric* boundary, a notion which turns out to be crucial in many cognitive spheres (cf. Smith, 1994);

iii) the employment of topological ideas and methods also in relation to *finite* domains of objects.

1.5.3 Husserl's topology

Another precursor of the idea of using topology as a foundation for human sciences (and, in nuce, cognitive sciences) is Edmund Husserl (1959-1938). Husserl's Logical Investigations (1900-01) contain a formal theory of part, whole and dependences that is used by the author to provide a framework for the analysis of mind and language of just the sort that is presupposed in the idea of a topological foundation for cognitive science.

The title of the third of Husserl's Logical Investigations is "On the Theory of Wholes and Parts" and it divides into two chapters: "The Difference between Independent and Dependent Objects" and "Thoughts Towards a Theory of the Pure Forms of Wholes and Parts". Husserl's theory is concerned also with the horizontal relations between the different parts within a single whole, relations which serve to give unity or integrity to the wholes in question (cf. Smith, 1994).

In other words, in Husserl's theory some parts of a whole exist merely side by side, they can be destroyed or removed from the whole without detriment to the residue. A whole all of whose parts manifest exclusively such "side-by-sideness" relations with each other is called a heap or aggregate or, more technically, a purely summative whole (*Und-Verbindung*). In many wholes, however, and one might say in all wholes manifesting any kind of unity, certain parts stand to each other in relations of what Husserl called necessary *dependence* (which is sometimes, but not always, necessary interdependence).

Such parts, for example the individual instances of hue, saturation and brightness involved in a given instance of colour, cannot, as a matter of necessity, exist, except in association with their complementary parts in a whole of the given type (cf. Smith, 1994).

There is a huge variety of such *lateral* dependence relations giving rise to correspondingly huge variety of different types of whole which more standard approaches of "extensional mereology" (cf. Casati and Varzi, 1999) are unable to distinguish. The connection between part and whole on the one hand and dependence on the other may be seen in the fact that every whole can be regarded as being dependent on its own constituent parts. It is one not inconsiderable advantage of Husserl's theory that it allows a precise formulation of these and a range of related theses within a single framework.

Roman Jakobson (1966) applied Husserl's ideas on parts, wholes and categories from the Logical Investigations in different branches of linguistics, in the early development of *categorial grammar* and of *phonology*, respectively.

Thus, Jakobson's account of distinctive features is as he himself admits an application of Husserl's idea[35].

1.5.4 Fillmore's frames and the "nouvelle vague" of topological semantics

Lullus's relational concept is elaborated by the concept of *valence*. Charles Fillmore would later (well, nine centuries later) call these *schemata* for the organization of concepts into a unitary macro-concept: *frames* (cf. Fillmore, 1977).

Fillmore has been extremely influential in the areas of syntax and lexical semantics; he was one of the founders of *cognitive linguistics*, and developed the theories of Case Grammar (1968), and Frame Semantics (1976). In all of his research he has illuminated the importance of semantics, and its role in motivating syntactic and morphological phenomena.

The framework of Case Grammar is a system of linguistic analysis, focusing on the link between the *valence* of a verb and the grammatical context it requires, created by Fillmore in the context of early Transformational Grammar. This theory analyzes the surface syntactic structure of sentences by studying the combination of deep cases (i.e. thematic roles) -- *Agent, Patient, Benefactor, Location or Instrument* -- which are

[35] The topological background of Husserl's work makes itself felt already in his theory of *dependence*. It comes to the fore above all however in his treatment of the notion of *phenomenal fusion* (a sort of *non-discrete* Merge?): the relation which holds between two adjacent parts of an extended totality when there is no qualitative discontinuity between the two. For example, adjacent squares on a chess-board array are not fused together in this sense; but if we imagine "a band of colour that is subject to a gradual transition from red through orange to yellow", then each region of this band is fused with its immediately adjacent regions (Smith, 1994).

required by a specific verb. For instance, the verb "give" in English requires an Agent (A) and Patient (P), and a Beneficiary (B); e.g. “Gianni (A) gives money (P) to Maria (B)”. Obviously, the heritage of Fillmore is still alive in contemporary generative grammar researches.

According to Fillmore, each verb selects a certain number of *deep cases* which form its case frame. Thus, a *case frame* describes important aspects of semantic *valency*, of verbs, adjectives and nouns. Case frames are subject to certain constraints, such as that a deep case can occur only once per sentence. Some of the cases are obligatory and others are optional. Obligatory cases may not be deleted, at the risk of producing ungrammatical sentences.

A fundamental hypothesis of case grammar is that grammatical functions, such as subject or object, are determined by the deep, semantic valence of the verb, which finds its syntactic correlate in such grammatical categories as Subject and Object, and in grammatical cases such as Nominative, Accusative, etc. Fillmore (1968) puts forwards the following hierarchy for an universal subject selection rule:

(5-1) [Agent < Instrumental < Objective]

That means that if the case frame of a verb contains an agent, this one is realized as the subject of an active sentence; otherwise, the deep case following the agent in the hierarchy (e.g. Instrumental) is promoted to subject.

Frame semantics is a topological theory that relates linguistic semantics to encyclopaedic knowledge developed by Fillmore, and is, in many respects, a further development of his Case grammar (cf. also Eco, 1975).

The basic idea is that one cannot understand the meaning of a single word without access to all the essential knowledge that relates to that word. For example, one would not be able to understand the word “sell” without knowing anything about the situation of commercial transfer, which also involves, among other things, a seller, a buyer, goods, money, the relation between the money and the goods, the relations between the seller and the goods and the money, the relation between the buyer and the goods and the money and so on.

Thus, a word activates, or evokes, a frame of semantic knowledge relating to the specific concept it refers to (or *highlights*, in frame semantic terminology). A semantic frame is defined as a coherent structure of related concepts that are related such that without knowledge of all of them, one does not have complete knowledge of one of the either, and are in that sense types of gestalt. Frames are based on recurring experiences. So the commercial transaction frame is based on recurring experiences of commercial transaction.

Words not only highlight individual concepts, but also specify a certain perspective in which the frame is viewed. For example "sell" views the situation from the perspective of the seller and "buy" from the perspective of the buyer. This, according to Fillmore, explains the observed asymmetries in many lexical relations.

While originally only being applied to lexemes, frame semantics has now been expanded to grammatical constructions and other larger and more complex linguistic units and has more or less been integrated into construction grammar as the main semantic principle.

Frame semantics has much in common with the semantic principle of *profiling* from Ronald W. Langacker's Cognitive Grammar.

Note that the concept of "frame" introduced in 1977 by Fillmore was anticipated by use of the term in Minsky (1975). Indeed, as stated by Wildgen (1994) in the seventies there was a sort of new impulse for applying topology to linguistics:

> "In 1977 Lakoff [*George*, my note] gave a paper on "linguistic Gestalts" at the Summer School on Mathematical and Computational Linguistics in Pisa. In the same period Leonard Talmy wrote articles titled "Rubber Sheet Cognition in Language" and "Figure and Ground in Complex Sentences", and in 1979 Langacker published the first article - entitled "Grammar as Image" - on what would become "space grammar" and later "cognitive grammar" (see above). Therefore, what Hjelmslev called the "localist hypothesis" in grammatical theory, especially with reference to the debates within nineteenth century German scholarship (Hjelmslev, 1943), seems to have returned as the methodological principle of "spatialization of form" in the second half of the twentieth century: the spatialization of forms (grammars) has been seriously followed by Charles Fillmore, Ronald Langacker and Len Talmy" (Wildgen, 1994: 37).

This kind of "localist" theory has been submitted to rigorous mathematical-topological formalization in the works of the French scientists René Thom and Jean Petitot.

Thom's *catastrophe*[36] *theory* is a mathematical framework that deals with discontinuous transitions between the states of a system, given smooth variation of the underlying parameters. The main thesis of the theory is that

[36] The term catastrophe, derived from the French in this usage, refers to the abrupt nature of the transitions, and does not necessarily bear negative connotations.

the parameter space of the system is a low dimensional projection of the state parameters and state relationships of the system, which are summarized as higher dimensional, smooth manifolds.

Apparent discontinuities or singularities in the parameter space of the system are explained as folds and cusps on the manifolds, thereby allowing the application of smooth differentiable models to discontinuous phenomena.

The theory is well defined for systems up to five input or control parameters, and one or two output or response variables. Low dimension catastrophe manifolds serve as good models and explanations of discontinuous transitions between alternative stable states in biological populations. In addition to the transitions, the models also explain the divergence between systems of slightly different initial conditions as those states evolve, as well as hysteresis in the reversal of state transitions.

Proceeding from Thom's catastrophe-theoretical modelling, Petitot in his *Morphogénèse du sens* (1985: not consulted but reconstructed from his article from 1989) goes on to propose a Kantian-type of schematisation of linguistic and semiotic structures. In developing structuralism as a cognitive theory of "morphodynamics", Petitot has also reinforced Gilles Deleuze's idea that structures are essentially "topological and relational", that is, even before they are filled with any specific content: what is assumed in this approach is an isomorphism between the dynamics of the rational interiority of the human mind and the physical dynamics of the external world (cf. Violi, 1987).

2. Graphs and Transformations

I give here a survey of some essentials of graph theory from a mathematical point of view, with major emphases on graph transformations including a translation of Chomsky grammars into graph grammars (showing the computational completeness of graph transformation).

Unfortunately, graphs are quite generic structures that can be encountered in many variants in the literature, and there are also many ways to apply rules to graphs. One cannot deal with all possibilities in an introductory survey (see Diestel, 2005).

I focus on *directed graphs* (syntactic trees are a special kind of directed, label-edged graphs), because directed graphs can be specialized into many other types of graphs, and I define graph grammars as a language-generating device with the more general notion of a transformation unit that models binary relations on graphs, following the work of Kreowski *et al.* (2006).

2.1 What a graph could be?

Graphs are well-suited and frequently-used structures to represent *complex relations* between objects of various kinds. They are the central structures of interest many areas of mathematics and computer science. But they are also popular and useful in many other disciplines like biology, chemistry, economics, logics, as we have introduced in the previous chapter.

Maps are typical examples of structures that are often represented by graphs. Already in 1736, Euler formulated the Konigsberger Brucken-problem concerning the map of Konigsberg, which consists of four areas that are separated from each other by the two arms of the river Pregel.

There are seven bridges connecting two areas each, and the question is whether one can walk around passing each bridge exactly once. This becomes a graph problem if the areas are considered as nodes and the bridges as edges between the corresponding nodes. A sketch of the map is shown below.

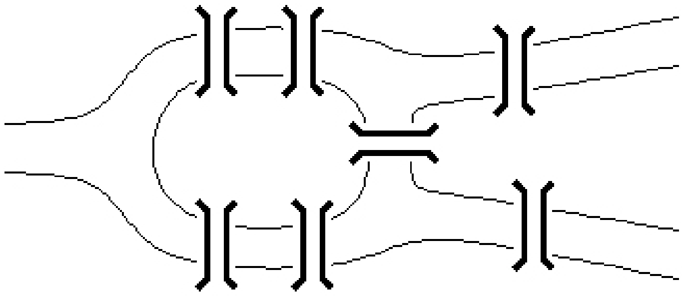


Fig. 2-1 The Seven Bridges of Königsberg

For such graphs, the general question (known as the *Eulerian Cycle Problem*) is whether there is a *cycle* passing each *edge* exactly once. Similarly, maps of countries can be represented as graphs by considering the countries as vertexes and by connecting each two vertexes with an edge the corresponding countries of which share a borderline.

In this way the famous *Four-Color-Problem* of maps becomes the Four-Color-Problem of graphs[37]. Finally, road maps are nicely represented as graphs by considering sites as nodes and a road that connects two sites directly as an edge that may be labelled with the distance. Such graphs are the basic data structures for various transportation and tour planning problems in logistics[38].

Graphs, however, are quite generic structures that can be encountered in the literature in many variants: directed and undirected, labelled and unlabeled, simple and multiple, with binary edges and hyperedges, etc. In this work, as I have already mentioned, I focus on directed, edge-labelled graphs.

[37] The four colour theorem (also known as the four colour map theorem) states that given any plane separated into regions, such as a political map of the states of a country, the regions may be colored using no more than four colours in such a way that no two adjacent regions receive the same color (Diestel, 2005). Two regions are called adjacent only if they share a border segment, not just a point. Each region must be contiguous: that is, it may not have *enclaves* like some real countries such as Russia with Kaliningrad/Königsberg (evidently the most notorious town for *topological* reasons) or even Toscana with *'Ca Raffaello*.

[38] Another typical example of graphs are Petri nets, which allow one to model concurrent and distributed systems (see Diestel, 2005). A Petri net is a simple bipartite graph meaning that there are two types of nodes, called *conditions* and *events* (or places and transitions), and a set of edges, called flow relation, which connect nodes of distinct types only (cf. Reisig, 1998).

2.2 An introduction of the basics and terminology of Graph Theory

"Graph Theory" is used to give a "pictorial representation" of any kind of relationship between entities. Some of the concepts of graph theory and some common terminology are presented here.

2.2.1 Directed and undirected Graphs, loops and walks

If we consider V as a finite non-empty set and E as a subset of the Cartesian product of V x V, then the pair (V, E) is called a *Directed Graph* or *Digraph* on V, denoted as $G = (V, E)$. The set V is the set of vertexes and E is the set of edges. When the directions of the edges are not considered then the graph is called an *Undirected Graph* (cf. Diestel, 2005). See below for examples of graphs:

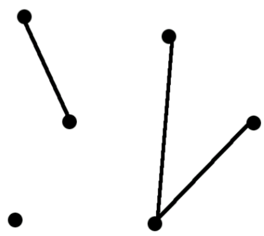


fig 2-2 examples of Graphs

An edge is said to be *incident* with the two vertexes it connects. A *loop* is an edge connecting a vertex to itself.

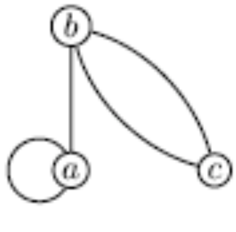


fig. 2-3 loops

A graph having no such edge is said to be *loop-free*. An *x-y walk* in G is a loop-free finite alternating sequence of vertexes and edges from G starting at vertex *x* and ending at vertex *y* involving a total of *n* edges $e_i = \{x_{i-1}, x_i\}$ where $1 \leq x \leq n$. The length of the *walk* is equal to the number of edges in the walk (n). When, n=0 and x=y then the walk is called a *trivial*. If x=y and n>1 then, it is *closed walk* else if x ≠ y then it is *open walk*. In a walk both the edges and the vertexes can be repeated.

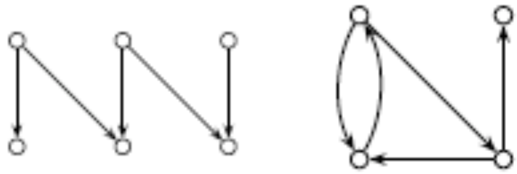


fig. 2-4 Directed graph (with and without loops)

Since, an edge interconnects two vertexes, that is, it is *incident* with the two vertexes, whenever the edge gets repeated the vertexes would have to be repeated. It would not be possible to repeat an edge and not to repeat vertexes. On the other hand, it would be possible to repeat vertexes, but not repeat the edges.

Fox example, if the set of vertexes is defined as:

(1-2)

V= {a,b,c,d,e,f}

and the set of edges

E = { {a,b}, {b,c}, {c,d}, {c,e}, {d,e}, {c,f}}

Then, the vertex c would get repeated once when we refer to edge {c,d} and second when we refer to the edge {c,e}. Then, for the topology under consideration, a b-f walk can be represented as:

(2-2) b,{b,c},c,{c,d},d{d,e},e{e,c},c,{c,f}.

2.2.2 Trails, paths and circuits

In an *x-y walk* when no edge is repeated it is called an *x-y trail* and when no vertex is repeated it is called an *x-y path*. A *closed x-x trail* is called a *circuit*, while, a *closed x-x path* is called a cycle. Whenever we talk about circuits, the convention is that we assume the existence of at least one *edge* (cf. Bollobás, 2001).

When there is only one edge the *circuit* becomes a *loop* (see above) and the graph is no longer *loop free*. If a trail exists in G between two vertexes, then there will be a path in G between the same two vertexes.

2.2.3 Connected and disconnected graphs

A graph G is said to be *connected* if there is a *path* between any two distinct vertexes of G, else it is said to be *disconnected*. A *multigraph* is one in which there exists multiple edges between the same pair of vertexes. The *multiplicity* of the edge between the pair of vertexes is given by the number of multiple edges between the pair of vertexes under consideration.

2.2.4 Subgraphs

A *subgraph* $G_1 = (V_1, E_1)$ is derived from a directed or undirected graph $G = (V, E)$ such that V_1 and E_1 are subsets of V and E and neither are null sets[39]. If $V_1=V$ then the subgraph is called a *spanning subgraph*.

An *induced subgraph* has a set of vertexes (U) which is a subset of the set of vertexes (V) of the graph (G) and contains all the edges present in G that are incident with the chosen subset of vertexes (cf. fig 2-5).

The constraint is that $U \neq 0$. Such a subgraph of G is said to be induced by U (Gibbons, 2002).

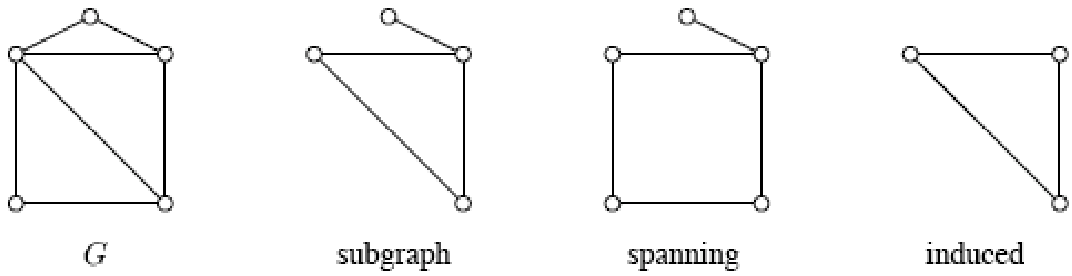


fig. 2-5 subgraph derivation

2.2.5 Complete graphs, isomorphism and degrees

A *complete graph* (K_n) on V, a set of 'n' vertexes, is a loop-free undirected graph where for all vertexes $x, y \in V$, and $x \neq y$, there is an edge. For a chosen value of 'n', there exists only one *complete graph*.

[39] It's interesting to notice that instead of removing nodes and edges, one may add some nodes and edges to extend a graph such that the given graph is a subgraph of the extension.
The addition of nodes causes no problem at all, whereas the addition of edges requires the specification of their labels, sources, and targets, where the latter two may be given or new nodes (cf. Kreowski et al. 2006).

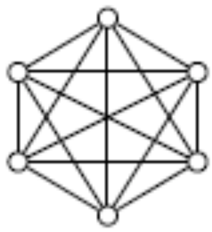


Fig. 2-6 complete graph

When we have two undirected graphs $G_1 = (V_1, E_1)$ and $G_2 = (V_2, E_2)$, a function $f: V_1 \rightarrow V_2$ is called a *graph isomorphism* if f is *one-to-one and onto* and for all vertexes x, y $\in V_1$ and edges {x, y} $\in E_1$ if and only if $\{f(x), f(y)\} \in E_2$. So, G_1 and G_2 are called *isomorphic graphs*.

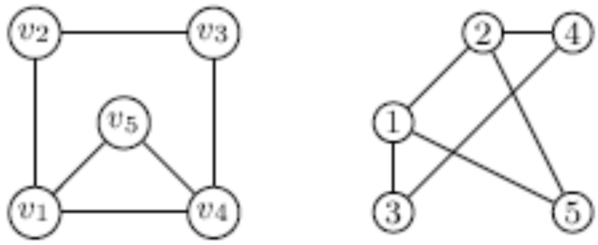


fig. 2-7 these graphs are isomorphic, Indeed, the required isomorphism is given by v1 -> 1; v2->2; v3->3; v4->4; v5->5

The *degree* of any vertex 'v', *deg (v)*, is the number of edges in the graph G that are incident with *v*. A loop at any vertex is counted as two edges. A degree of 1 for any vertex makes it a *pendant vertex*. An undirected graph (or multigraph[40]) with the same degree for each vertex is called a *regular graph.*

The *incoming*, or *in*, *degree* of *v* is the number of edges in G that are incident into *v*. It is denoted by *id (v).* The *outing*, or out, *degree* of *v* is the number of edges in G that are incident from *v*. It is denoted by *od (v).* A loop at a vertex contributes a count of one to both *in-degree* and *out-degree*.

2.2.6 Planar and bipartite graphs

The graph G is called a *planar graph* if G can be drawn in the plane of a paper with its edges intersecting only at vertexes of G; else it is called a

---

[40] So, the *Euler circuit* in an undirected graph (or multigraph), G = (V, E), with no isolated vertexes, is one that traverses every edge of the graph exactly once. Since the Euler circuit traverses every edge of the undirected graph exactly once, it is not possible to have two distinct Euler circuits for the same graph. An open trail that traverses each edge only once is called an *Euler trail* (cf. Gibbons, 2002)

nonplanar graph. A graph G = (V, E) is said to be *bipartite*, if $V = V_1 \cup V_2$ with $V_1 \cap V_2 = 0$, and every edge of G is of the form {x, y} with $x \in V_1$ and $y \in V_2$. If each vertex in V_1 is connected to every vertex in V_2, then it is a *complete bipartite graph*. If $|V_1|=m$ and $|V_2|=n$ then the graph is denoted by $K_{m,n}$.

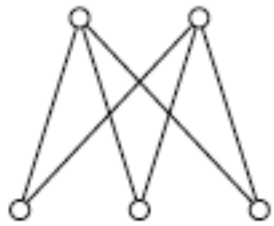


fig. 2-8 A complete bipartite graph

2.2.7 Elementary subdivisions

In G = (V, E) a loop-free undirected graph, the operation of removing an edge e = {a, c} and adding the edges {a, b}, {b, c} to G-e, where $b \notin V$ is called *elementary subdivision*.

The loop-free undirected graphs $G_1= (V_1, E_1)$ and $G_2= (V_2, E_2)$ are called *homeomorphic* if they are *isomorphic* or if both of them can be obtained from the same loop-free undirected graph by a sequence of *elementary subdivisions*[41].

2.2.8 Hamilton Graphs

The graph G = (V, E) with $|V| \geq 3$, has a *Hamilton cycle* if there is a cycle in G that contains every vertex in V. A *Hamilton path* is a path in G that contains each vertex[42].

---

[41] The *Kurotowski's theorem* states that a graph is nonplanar if and only if it contains a subgraph that is *homeomorphic* to either K_5 or $K_{3,3}$ (Cf. Grimaldi, 2005).

[42] In a famous topographic problem, the *travelling salesman* problem a person is supposed to visit each town in his district, and this he should do in such a way that saves time and money. Obviously, he should plan the travel so as to visit each town once, and so that the overall flight time is as short as possible. In terms of graphs, he is looking for a minimum weighted Hamilton cycle of a graph, the vertices of which are the towns and the weights on the edges are the flight times. it is widely believed that no practical algorithm exists (cf. Diestel, 2005).

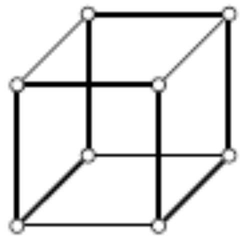


fig. 2-9 An Hamilton cycle

2.2.9 Colouring a graph

A *proper colouring* of an undirected graph G= (V, E) occurs when each of the vertexes of G are coloured so that if {x, y} is an edge in g then *x* and *y* are coloured with different colours, that is adjacent vertexes have different colours. The minimum number of colours needed to properly colour G is called the *chromatic number* of G (cf. footnote 37).

2.3 Trees

Let's now - given some basic principles and a terminology - try to define a (syntactic) tree into graph theoretical terms. In general terms, a tree is useful as a pictorial representation of structure. As a device for representing structure, it is applicable to any situation where a *hierarchy* of choices is made. A *derivation* is a perfect example of a hierarchy of choices, and as such a tree is ideal as a visual representation of a derivation. To construct a derivation tree, we start with a tree containing only the *root* node. For each step of the derivation, the tree is correspondingly extended. That is, every time a production is used to replace a non-terminal in the current sentential form by the string on the right hand side of the production, lines are drawn from the corresponding non-terminal in the tree to each symbol in the replacement string (cf. Harju, 2005). At each stage in the construction of the tree, reading from left to right, the leaf nodes will be the current sentential form. In formal language theory, and specifically in generative linguistics, tree diagrams are much used, and a tree diagram is an acyclic, connected graph. Here's a definition:

(3-2) *A loop-free, undirected, connected graph G= (V, E) which has no cycles is called a tree and is denoted by T= (V, E).*

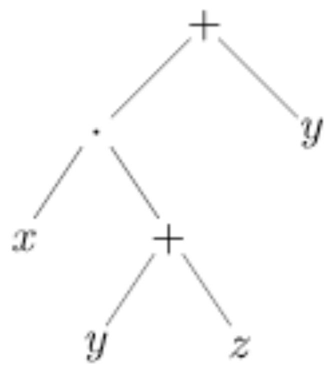


fig. 2-10 A tree of operations for the arithmetic formula x(y+z)+y

The spanning subgraph, for a connected graph, which is also a tree is the *spanning tree*[43]. It provides minimal connectivity between all vertexes of the graph. There are two algorithms, according to Diestel (2005) to search for the spanning tree in a graph:

i) *Depth First Search* algorithm[44]
ii) *Breadth First Search* algorithm[45].

If G is a directed graph and the undirected graph associated with G is a tree, then G is a *directed tree*. It is a *rooted tree* if there is a unique vertex '*r*' (*root*) such that the in-degree of r, id(r) =0 and for all other vertexes (*v*) the in-degree, id (v) =1. The vertex with out-degree, out (v) =0 is the *leaf* or *terminal vertex*. All other vertexes are *branch nodes* or *internal vertexes*. The *subtree* at

[43] Spanning trees are often optimal solutions to problems, where cost is the criterion. We may also wish to construct graphs that are as simple as possible, but where two vertices are always connected by at least two independent paths. These problems occur especially in different aspects of fault tolerance and reliability of networks, where one has to make sure that a breakdownof one connection does not affect the functionality of the network. Similarly, in a reliable network we require that a break-down of a node (computer) should not result in the inactivity of the whole network (cf. Harju, 2006)

[44] Intuitively, in a deep-first search one starts at the root (selecting some node as the root in the graph case) and explores as far as possible along each branch before backtracking. Formally, a deep-first search DFS is an uninformed search that progresses by expanding the first child node of the search tree that appears and thus going deeper and deeper until a goal node is found, or until it hits a node that has no children. Then the search backtracks, returning to the most recent node it hadn't finished exploring. Cf T.H. Cormen, C.E. Leiserson And R.L. Rivest, *Introduction to Algorithms*, MIT Press, 1993.

[45] Breadth-first search algorithm begins at the root node and explores all the neighbouring nodes. Then for each of those nearest nodes, it explores their unexplored neighbour nodes, and so on, until it finds the goal. Cf T.H. Cormen, C.E. Leiserson And R.L. Rivest, *Introduction to Algorithms*, MIT Press, 1993.

any vertex is the subgraph induced by that vertex as root and all of its *decedents.* If the edges or branches of the rooted tree are ordered then it is called an *ordered rooted tree*. Given $m \in Z^+$, a rooted tree T = (V, E) is an *m-ary tree* if for all vertexes the od (v) ≤ m. When m =2 it is a *binary tree.* If od (v) = 0 or m for all $v \in V$ then T is called a *complete m-ary tree*. For m=2, it is a *complete binary tree* and can be used to represent binary operations. In a complete m-ary tree each internal vertex has exactly *m-children*. If T is a complete binary tree of height *h* and all the leaves in T are at level *h* then, T is called a *full binary tree*.

The *level number* is the number of paths from the root vertex to the vertex under consideration. If *h* is the largest level number achieved by a leaf of T= (V, E), then, T is said to have a *height h.* A rooted tree of height *h* is *balanced* if the level number of every leaf in T is (*h-1*) or *h*. A vertex *v* in a loop-free undirected graph G = (V, E) is called an *articulation point* if the subgraph G-v has more components than the given graph G.

The removal of the articulation points disconnects the graph. In terms of communications systems and networks the articulation points indicate locations where the system is most vulnerable.

A loop-free connected undirected graph without any articulation points is called *biconnected* and is said to be a "nonseparable graph". A graph with weights assigned to its edges is called a *weighted subgraph*. *Weights* are positive real numbers attached to the edges. The might signify parameters such as cost, time, length etc. on each edge considered as a link. If $x, y \in V$, but $(x, y) \notin E$ then $wt(x, y) = \infty$. A set P of binary sequences (representing a set of symbols) is a *prefix code* if no sequence in P is the prefix of any other sequence in P. When a sequence of binary characters (0 and 1) are used to represent symbols, then, care should be taken that the binary code for one symbol does not form a prefix to the code of another symbol, else decoding will be difficult and might be incorrect.

2.3.1 The Shortest path and the Minimal spanning tree problems

In our discussion, I think that is relevant to introduce this two problems and their solutions.

The *shortest path problem* arises whenever there is a need to determine the shortest, cheapest, or most reliable path between one or many pairs of nodes in a network.

The *minimal spanning tree problem* occurs when we need to design the simplest network (a spanning tree) that will connect topologically dispersed system components so that they can communicate with each other and the total construction cost is minimized.

The shortest path problem differs from the minimum spanning tree problem in that, the former is used to find the cheapest path between some nodes, while the latter is to find the cheapest tree that connects every node (cf. Diestel, 2005).

Many of the most salient core ingredients of network techniques are captured by the shortest path problem. It is often encountered in the transportation and communication networks.

2.3.1.1 Dijkstra' Shortest Path algorithm

In a given weighted directed graph G= (V, E) the shortest path between any two vertexes is that path in which the sum of weights of all the constituent edges is the minimum. The main idea of the algorithm is to change the temporary labels associated with vertexes into permanent ones. The permanent label of a vertex denotes the shortest path weight from the source vertex to the current vertex.

The source vertex is given a permanent label (0,-) and each of the other vertexes is given a temporary label (∞,-). Let P and P' (= V-P) be the sets containing vertexes with permanent and temporary labels respectively. At each step, the algorithm chooses the vertex $x \in P'$ with the minimum temporary label, and makes it permanent, records its predecessor's index and updates the temporary values of all the vertexes. It repeats this procedure till all nodes get permanent labels (cf. Harju, 2005).

2.3.1.2 Kruskal's Minimal Spanning tree algorithm

The main idea of this algorithm is to add at each step the cheapest edge (lowest weight) from the set of remaining edges. The subgraph developed at each step should not contain any cycles. Initially the counter *i* is set to 1 and an edge e_1 in G= (V, E) is selected with the lowest weight.

If edges e_1, $e_2 \ldots e_i$ have been selected for $1 \leq i \leq n-2$ where $n = |V|$, then, ei_{+1} is selected such that it has the lowest weight among the remaining edges and the subgraph being formed does not contain any cycles. Subsequently, *i* is replaced by *i+1*.The procedure is repeated till *i< n-1*.If *i = n -1* then the subgraph of G determined bys the edges e_1, $e_2 \ldots e_{n-1}$ is connected with *n* vertexes and *n-1* edges and is the minimal spanning tree for G (cf. Harju, 2006).

2.3.1.3 Prim's Algorithm

This gives the "optimal tree" for a graph. Initially the counter *i* is set to 1 and an vertex $v_1 \in V$ is placed in set P. Now N and T are defined as N = V-{v_1} and T =0. For $1 \leq i \leq n-2$ where n = $|V|$, P is the set of vertexes and T is the set of edges and N = V-P. The edge of minimal weight in G that connects a vertex x in P to a vertex y (= v_{i+1}) in N is added to the set T. Now, y is placed in set P and deleted from N. The counter is incremented by 1. The process is repeated till i=n. If $i = n$ then the subgraph of G determined by the edges e_1, $e_2 \ldots e_{n-1}$ is connected with *n* vertexes and *n-1* edges and is the optimal spanning tree for G. (cf. Diestel, 2005).

2.4 Graph transformations

Graph transformation is a rule-based method that performs local changes on graphs (Diestel, 2005). With graph transformation rules it is possible to specify formally and visually for instance the semantics of rule-based systems (like the semantics of functional languages), specific graph languages, graph algorithms (like the search of all Eulerian cycles in a graph), and many more.

The idea of a graph transformation rule is to express which part of a graph is to be replaced by another graph. Unlike strings, a subgraph to be replaced can be linked in many ways (i.e., by many edges) with the surrounding graph. Consequently, a rule also has to specify which kind of *links* are allowed; this is done with the help of a third graph that is common to the replaced and the replacing graph and requires that the surrounding graph may be linked to the replaced graph only with edges incident to this third graph (cf. Kreowski *et al.* 2006).

Here is a formal definition of a rule of graph transformation, taken from Kreowski *et al.* (2006: 6):

(4-2) A rule $r = (L \supseteq K \supseteq R)$ consists of three graphs L; K; R such that K is a subgraph of L and R. The components L, K, and R of *r* are called *left-hand side*, *gluing graph*, and *right-hand side*, respectively.

Here I show, following Kreowski *et al.* (2006), a simple example, concerning shortest paths. The figure below shows the two essential rules for the computation of shortest paths in distance graphs, that is graphs labeled with non-negative integers. The first rule adds (r_{add}) a direct connection between each two nodes that are connected by a path of length 2 and sums the distances up.

Using this rule, one can compute the transitive closure of the given distance graph. If one applies the second rule (r_{select}), which chooses the shortest connection of two direct connections as long as possible, one ends up with shortest connection between each two nodes.

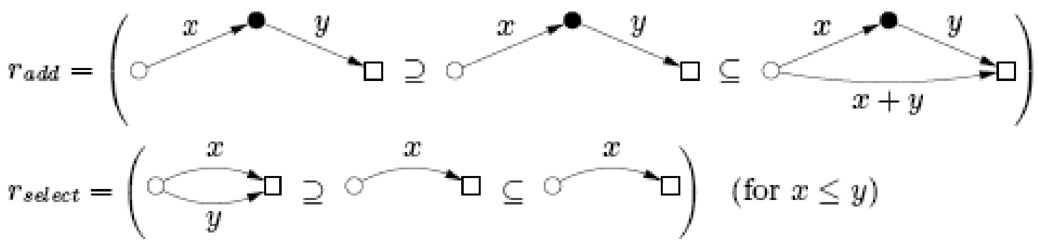


Fig. 2-11. Graph transformation rules for the computation of shortest paths, taken from Kreowski et al. (2006; p. 7)

2.5 Graph Languages

Analogously to Chomsky grammars (see paragraph 2.7) in formal language theory, graph transformation can be used to generate graph languages. A graph grammar consists of a set of rules, a start graph, and a terminal expression fixing the set of terminal graphs (cf. Ehrig *et al.* 1999).

Such a terminal expression may consist of a set $\Delta \subseteq \sum$ of terminal labels admitting all graphs that are labeled over Δ.

Here is formal definition of a graph grammar:

(5-2)

A graph grammar is a system [GG] = (S; P; Δ) where S is the initial graph of GG, P is a finite set of graph transformation rules, and $\Delta \subseteq \sum$ is a set of terminal symbols. The generated language of GG consists of all graphs G that are labeled over Δ and that are derivable from the initial graph S via successive application of the rules in P (Kreowski *et al.* 2006: 14).

I give an example of a grammar generating connected graphs (see paragraph 2.2.).

Consider *connected* = {°; P; *} where the start graph consists of a single node and the terminal expression allows all graphs labeled only with * . Note that the symbol * denotes a special label in $\sum$ standing for unlabeled and being invisible in displayed graphs (cf. Gibbons, 2002).

The rules in P = {*p1; p2; p3*} are depicted in Figure 2-12. The rule *p1* adds a node *v* and an edge *e* such that *v* is the target of *e*, and takes as source of *e* an already existing node. The rule *p2* is similar, the only difference being that the direction of the new edge *e* is inverted. The third rule *p3* generates a new edge between two existing nodes. The new edge can also be a loop if the two nodes in the left-hand side of *p3* are identified, for example, if they are one and the same node in the match of the left-hand side. It can be shown that the generated language of *connected, L(connected),* consists of all non-empty connected unlabeled graphs.

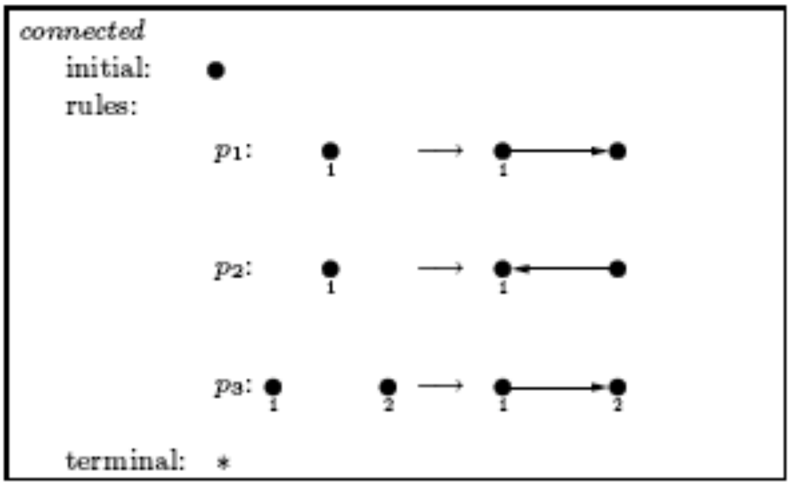


Fig. 2-12. Rules for the generation of a (connected) graph

2.6 Formal grammars and linguistic theory

I give in this section a rough presentation of Chomsky Grammars, before applying a translation of Chomsky Grammars into Graph Grammar (see above), in the final paragraph of this chapter concerning graph theory's formalisms.

In linguistics a formal grammar is a precise description of a formal language — that is, of a set of strings over some alphabet. The two main categories of formal grammars are *generative grammars,* which describe how to *write* strings that belong to a given language (*generate*), and *analytic grammars,* which describe how to *recognize* when strings are members in the language (*analyze*).

2.6.1 Chomsky hierarchy

The Chomsky hierarchy is a "containment hierarchy" of classes of formal grammars. This hierarchy of grammars was described by Noam Chomsky in 1957. Generative grammar consists of a *set* of *rules* for transforming *strings*. To generate a string in the language, one begins with a string consisting of only a single *start symbol*, and then successively applies the rules (any number of times, in any order) to rewrite this string. The language consists of all the strings that can be generated in this manner. Any particular sequence of legal choices taken during this rewriting process yields one particular string in the language. If there are multiple different ways of generating a single string, then the grammar is said to be ambiguous.

For example, assume that the alphabet consists of *a* and *b*, the start symbol is *S* and we have the following rules:

$A.\ S \rightarrow aSb$

$B.\ S \rightarrow ba$

Then, we start with *S*, and can choose a rule to apply to it. If we choose rule A, we obtain the string *aSb*. If we choose rule A again, we replace *S* with *aSb* and obtain the string *aaSbb*. This process is repeated until we only have symbols from the alphabet (i.e., *a* and *b*). If we now choose rule B, we replace *S* with *ba* and obtain the string *aababb*, and are done.

We can write this series of choices more briefly, using symbols:

$S \rightarrow aSb \rightarrow aaSbb \rightarrow aababb$

The language of the grammar is the set of all the strings that can be generated using this process:

{ba, abab, aababb, aaababbb…}

In the classic formalization of generative grammars first proposed by Chomsky in the 1950s, a grammar *G* consists of the following components:

1) A finite set *N* of *nonterminal symbols*.
2) A finite set Σ of *terminal symbols* that is disjoint from *N*.
3) A finite set *P* of *production rules*, each of the form
4) 4) A distinguished symbol $S \in N$ that is the *start symbol*.

If a production rule is written as $\alpha \rightarrow \beta$, then we may distinguish four general types, depending on what forms α and β are permitted to take. Each of these types generates a different family of languages, and for each family there is a machine that is capable of generating or recognizing the languages. These types form a hierarchy, in the sense that the set of languages generated by *Type k* grammars is a proper subset of the languages generated by *Type (k-1)* grammars. This hierarchy is known as the Chomsky hierarchy.

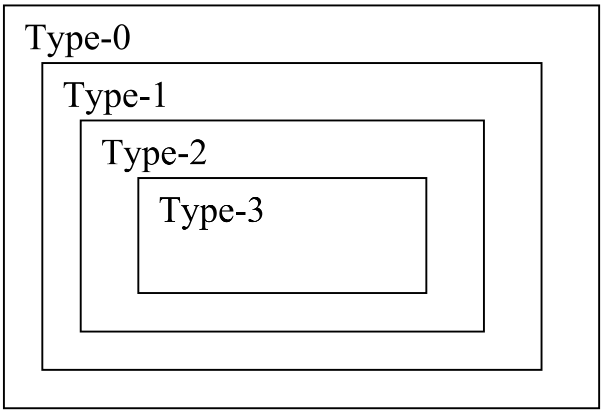


Fig. 2-13 The Chomsky hierarchy

2.6.2 Type 0 grammars (unrestricted)

α and β can be any strings of symbols; the sole restriction is that α may not be the null string. A typical production, however, is of the form $\gamma A\delta \rightarrow \gamma\beta\delta$. Here A is some nonterminal; γ and δ are the left and right contexts, respectively, of A. Type 0 grammars are also known as unrestricted grammars, phrase-structure grammars, or *semi-Thue*.

2.6.3 Type 1 grammars (context-sensitive)

The productions take the same form $\gamma A\delta \rightarrow \gamma\beta\delta$ as in Type 0 grammars, except that β may not be ε. As a result of this restriction, the sentential forms in the derivation steps always grow longer as you go through the derivation. Type 1 grammars are known as context-sensitive grammars.

2.6.4 Type 2 grammars (context-free)

The left-hand side of the production is a single nonterminal. Thus productions take the form A $\rightarrow$ β. Type 2 grammars are the context-free grammars (CFGs).

We said that in Type 1 grammars, the nonterminal on the left-hand side could not be replaced by ε. Since these restrictions are cumulative as we go from one level of the hierarchy to the next, this implies that Type 2 grammars may not have productions of the form A → ε. In fact, we will see many CFGs having such productions; we must allow such productions as exceptions to the Type-1 restriction.

It takes a stack automaton to recognize context-free languages. A stack automaton is a *FSA* equipped with temporary storage in the form of a pushdown stack.

CFGs are the grammars we use in syntactic analysis. Every parser we study uses a stack, either explicitly or implicitly.

To recognize the full set of context-free languages, we require a non-deterministic stack automaton. However, practical programming languages belong to a subset that can be adequately described by deterministic CFGs.

2.6.5 Type 3 grammars (regular)

The right-hand side of every production may be only:

(a) a single terminal,
or
(b) a single nonterminal followed by a single terminal.

These are the regular grammars.

2.6.6 Use of Chomsky hierarchy

Type 0 and Type 1 grammars are less well understood; there are no simple ways of constructing parsers for them, and parsers for these languages are slow.

Type 1 (context-sensitive) grammars are sometimes used to describe the semantics of programming-language. But, natural languages are frequently used for semantics.

Type 2 (CFGs) grammars can define most of the rules required in programming languages, and the few things that can't be defined by them are easily managed by other means.

We can handle regular languages in lexical analysis well enough by the *DFA* model, so we have little need for Type 3 grammars.

Note that the set of grammars corresponding to *recursive* languages is not a member of this hierarchy. Every regular language is context-free, every context-free language is context-sensitive and every context-sensitive language is recursive and every recursive language is recursively enumerable. These are all proper inclusions, meaning that there exist recursively enumerable languages that are not context-sensitive, context-sensitive languages that are not context-free and context-free languages that are not regular.

As mentioned above, in computational linguistics, context free and regular grammars are by far the most important. Unrestricted grammars are occasionally invoked, but it is rare to find any reference to context sensitive ones (cf. Jurafsky & Martin, 2000).

2.7 Transformation of Chomsky grammars into graph grammars (Kreowki et al. 2006)

Intuitively, it may be clear that graph transformation is computationally complete (cf. paragraph 2.4). This claim is made precise in this final section of the chapter by translating Chomsky grammars into graph grammars. The translation is based on Kreowski *et al.* (2006) and on the observation that:

(6-2) a string $x = a_{i\ldots}a_k$ with $a_i \in \sum$ for $i = 1\ldots k$

can be represented by a so-called string graph $x°$ that consists of $k + 1$ nodes and k edges, where for $i = 1\ldots k$ the source of the ith edge is the ith node, the target is the $(i+1)$th node, and the label is $a_{i.}$ (the first and the last nodes are denoted by b(x°) and e(x°), respectively, cf. Diestel, 2005)

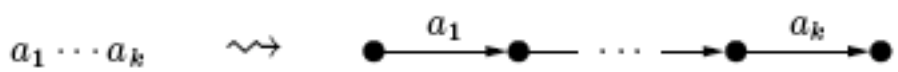


Fig. 2- Translating a string into a graph

Let's try an explanation.

Let CG = (N; ∑; S; P) be a Chomsky grammar (cf. the previous paragraph), assuming that the right-hand side of every production is not empty [for example for all productions $u \rightarrow v$ in P we have $v \neq \lambda$]. Such a production p is translated into a graph transformation rule r_p as follows (consider also for an extended demonstration: Kreowski *et al.* (2006)).

Let $u°$ and $v°$ be string graphs associated with u and v, respectively, such that $b(u°) = b(v°)$ and $e(u°) = e(v°)$. Then let $r_p = (u° \supseteq be \subseteq v°)$ with *be* the graph consisting of the two nodes $b(u°)$ and $e(u°)$ be the graph transformation rule associated with p.

Since the edges in a string graph are directed (cf. paragraph 2.1), there exists "a match of $u°$ in a string graph $x°$ if and only if u is a substring of x" (Kreowski *et al.* 2006; p. 14). In other words, the rule r_p may be applied to $x°$ if and only if the production p can be applied to x.

The results of the applications correspond, too, so that Kreowski *et al.* (2006: 15) state the following theorem (I give here a slightly modified version):

(7-2)
Theorem of a Correct Translation.

Let $CG = (N; \sum; S; P)$ *be a Chomsky grammar with* $v \neq \lambda$ *for all* $u \to v$ *in* P.

1. Let $x, y \in (N \cup \sum)$ *and* $p \in P$. *then* $x \to_p y$ *if and only if* $x° \to_{rp} y°$.
2. Let $CG° = (S°; P°; \sum)$ *with* $P° \{r_p \mid p \in P\}$ *the graph grammar associated with* CG. *Then* $L(CG°) = L(CG)° = \{x° \mid x \in L(CG)\}$.

So, in the case of a Chomsky grammar of type 1 or higher[46], we may assume that there is only the production $S \to \lambda$ with empty right-hand side, and this only if S does not occur in the right-hand side of any other production.

Thus, we may use the graph transformation rule $S° \supseteq {}_{\text{EMPTY}} \subseteq \lambda°$ where ${}_{\text{EMPTY}}$ denotes the empty graph.

In the case of a Chomsky grammar of type 0, we may eliminate each production $u \to v$ by replacing it with all productions of the form $ua \to a$ and $au \to a$, where $a \in N \cup \sum$. If the original grammar generates the empty word, a new axiom S' and productions $S' \mid \lambda$ must be added. So, the constructions given above can be used.

[46] Note that as a consequence of the Correct Translation Theorem, all undecidability results (i.e emptiness, finiteness, membership, inclusion, and equivalence problems known for Chomsky grammars transfer to graph grammars).

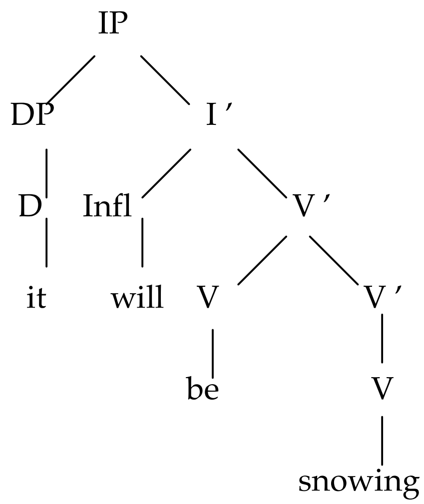
3. From bare phrase structure to syntactic graphs

In this section I try to explain the way in which lexical graph (as defined below) could capture in an elegant (and minimal) fashion important syntactic relations commonly *expressed* in standard tree representations.

3.1 Graphs and X′-Theory

A representation of phrase structure (cf. Jakendoff, 1977; Haegeman, 1996) such as (1-3) is a kind of *directed graph* (cf paragraph 2.2):

(1-3) It will be snowing



A directed graph G, by the definition given in Diestel (2005), consists, *roughly*, as we have said in the previous Chapter, of a finite set of nodes/vertex (V) and a finite set of ordered pairs of nodes/edges (E) that express immediate *domination* relations. So, the syntactic structure given in (1-3) is nothing more than G=(V, E), as defined in (2-3):

(2-3)
V (all the vertexes) =
{IP, D′, I′, D, INFL, V′, V, V′, V, it, will, be, snowing}
E (all the edges) =
{<IP, D′>, <IP, I′>, <D′, D>, <I′, INFL>, <I′, V′>, <V′, V>, <V′, V′>, <V′, V>, <D, it>, <INFL, will>, <V, be>, <V, snowing>}

Besides the defining properties as a directed graph, a phrase structure diagram has been assumed (cf. Haegeman, 1996) to have properties such as:

(a) There is one vertex, called the root vertex, that is dominated by no vertexes and from which there is a path to every vertex, where a path is any linear subset of a tree (cf. Chapter 2).

(b) Every vertex other than the root has exactly one vertex that immediately dominates it.

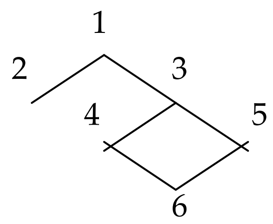
(c) The vertexes that each singular vertex immediately dominates are ordered from the left (or better, temporally); as a corollary of (c):

(c1) says that a well-formed sentence needs to constitute a (single) connected graph with one special vertex as its root.

(c2) need not (or should not be retained within the minimalist program), where linear order is assumed to play no significant syntactic role.

The postulates (c1) and (c2) has been adopted in virtually every theory of phrase structure, and it specifically excludes a diagram (cf. Yasui, 2004a) with a closed route such as (3-3):

(3-3)



The problematic node is clearly 6, which is dominated by two nodes, 4 and 5; thus, the structure given in (3-3) violates what assumed in (c2).

Whether (c2) should be assumed or not depends merely on other assumptions on phrase structure. I try to show in the present contribution that a graph-based analysis of some of the fundamental assumptions in the minimalist program leads to the rejection of (c2) (or the growth of a linear model).

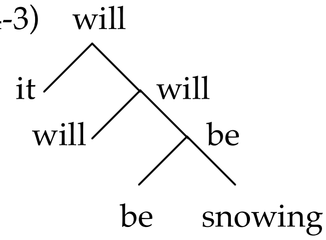
In the syntactic graphs, to be proposed below, in fact the output of external MERGE is a tree with the property (c2) but that of internal MERGE (or movement) is a graph that has a "closed route"[47].

[47] This distinction could offer a natural explanation for the parametric difference in wh-movement; the PF requirement of linearizing lexical items forces a graph with a closed route to be changed into a tree in either of the two possible ways, which correspond to *ouvert* and *covert* movement.

3.2 Graphs and Bare phrase structure

One important simplification of phrase structure proposed since Chomsky (1994, 1995: Chapter 5) is the elimination of category and projection labels by the extensive use of lexical items themselves, which is motivated by the Inclusiveness Condition[48]. To meet the Inclusiveness Condition, (4-3) is to be assumed instead of (1-3) (=(2-3) in our revision from a graph theoretic point of view).

(4-3)



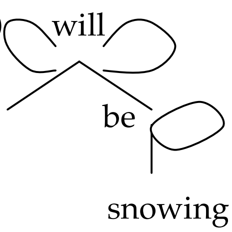
V = {it, will, will, will, be, be, snowing}

E={<will, it>, <will, will>, <will, will>, <will, be>, <be, be>, <be, snowing>}

The structure given in (4-3) contains nodes with the same labels *will* and *be*. If nodes with the same label are to be identified as one (cf. Yasui, 2004a), the set V in (4) is non-distinct from {it, will, be, snowing}.

Then, (4-3) is forced to be replaced by (5-3):

(5-3)



V={it, will, be, snowing}

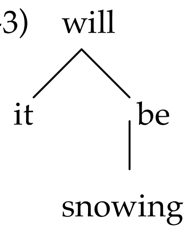
E={<will, it>, <will, will>, <will, will>, <will, be>, <be, be>, <be, snowing>}

---

[48] The Inclusiveness Condition says that the output of a system does not contain anything beyond its input. It was first proposed in Chomsky (1995: 225) as a condition met by the computational system of human language, and taken to imply that the interface levels contain nothing more than arrangements of lexical features. In other words, a language which meets the inclusiveness condition cannot contain traces or indices left after movement.

The structure in (5-3) contains three loops (cf. paragraph 2.2), <will, will>, <will, will> and <be, be>, which express nothing other than intermediate projections (so they can be rejected; erased). Therefore, (6-3) is to be finally assumed here:

(6-3)



V={it, will, be, snowing}
E={<will, it>, <will, be>, <be, snowing>}

The structure in (6-3) might not look like a syntactic tree, but the set of nodes V is essentially the e*numeration* in the sense of Chomsky (1995: 225-227), and E in (6-3) seems to meet the Inclusiveness Condition just because *no* projection and category labels are added (a similar conclusion is found in Yasui, 2004a).

Furthermore, the order pair $\langle\alpha, \beta\rangle$ is generally defined as $\{\{\alpha\}, \{\alpha, \beta\}\}$, and it looks quite close to Chomsky's (1995:244-245) definition of the object formed from α and β of the type α: $\{\alpha, \{\alpha,\beta\}\}$. If $\{\alpha, \beta\}$ is adopted instead of $\{\alpha, \{\alpha,\beta\}\}$ as the definition of the object formed from α and β, the discrepancy between the formal definition and its graphical representation can disappear, which seems to be an interesting result (cf. Collins, 2002).

In this graph theory based account for syntactic structure, it is evident that my primary influence (my debt) is the paper of Collins (2002), that is a sort of *quest* for a label free syntax.

3.3 External and Internal Merge

First, let's consider external MERGE, which is applied to two substructures α and β and produces a larger structure only if some syntactic relation holds between α and β (cf. Starke, 2001). To paraphrase it in the terms of a linguistic graph theory, MERGE is a kind of "*linking operation*" over two graphs[49], with

[49] According to the standard conception of syntactic structure, merging lexical items, α and β, is represented by the tree in (i), with no order assumed.

(i)

an ordered pair added to the linking process. It is formally defined as (7-3):

(7-3) MERGE definition in topological network terms:

Given two graphs G1 =(V1, E1) and G2=(V2, E2),
MERGE (G1, G2) give a graph G=(V, E) such that

(i) $V = V1 \cup V2$ and

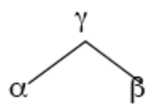
(ii) For some $v1 \in V1$, $v2 \in V2$, $E = E1 \cup E2 \cup \{<v1, v2>\}$ or $E = E1 \cup E2 \cup \{<v2, v1>\}$

The resulting set of vertexes is simply the union of the *E sets* of the two input graphs (this fact is crucial for the driftage of Chapter, 5). Some vertex in one graph enters into a local syntactic relation with some vertex in the other graph, whereby the two graphs are combined[50]. Tentatively, a derivation starts with a set of *minimal* graphs, each of which consists of a single lexical item, chosen from the lexicon before the connection among the items take place. For instance, the example in (4-3) could starts with (8-3)

(8-3) . it . will . be . snowing
G1=(V1, V2): V1={it}, E1=∅
G2=(V2, E2): V2={will}, E2=∅
G3=(V3, E3): V3={be}, E3=∅
G4=(V4, E4): V4={snowing}, E4=∅

Since the auxiliary *be* selects the progressive form of a verb (*snowing*), the ordered pair <be, snowing> is introduced as in (9-3):

(9-3) . it . will . be
.snowing



The new node γ is introduced along with two directed edges connecting it with α and β. α and β are pronounced but γ has no phonetic value. If γ is the same type as α, α is the head of the structure labeled as γ, and α selects or agrees with β. The syntactic relation is reversed if γ is the same type as β (cf. Yasui, 2004b).

[50] I assume that is the first member of each ordered pair to select the second member or to agree with it with its *EPP feature* (cf. Boskovic, 2002).

MERGE(G3, G4) = G5=(V5, E5)
Where V5=V3∪V4={be, snowing}
And E5=E3∪E4 {<be, snowing>}={<be, snowing>}

Then, the item *Will* selects[51] verbal and also case-checks for nominative; thus, the recursive application of MERGE will convert (9-3) into (10-3) and then (11-3) (=(6-3)):

(10-3) . it . will

. be

. snowing

MERGE (G2, G5)=G6=(V6, E6)
V6=V2∪V5={will, be, snowing}
E6=E2∪E5∪ {<will, be>}={<will, be>, <be, snowing>}

(11-3) . it

. will

. be

. snowing

MERGE (G1, G6)=G7=(V7, E7)
V7=V1∪V6={it, will, be, snowing}
E7=E1∪E6∪ {<will, it>}={<will, it>, <will, be>, <be, snowing>}

It does not matter which of the ordered pairs in E7 is added first. For example, it is easy to verify that adding the pair <will, it> before <will, be> or <be, snowing> will make the same result.

It is important to notice that MERGE as defined in (7-3) does not prevent a graph from being combined with itself. This is, in fact, an instance of an

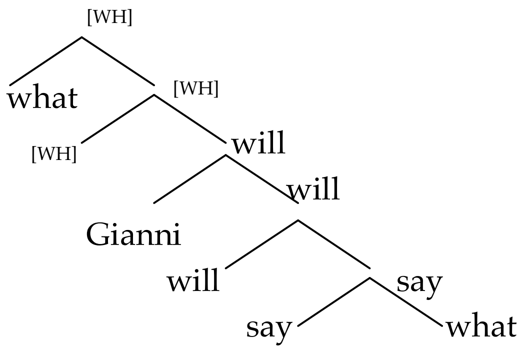
[51] It is possible to find some similarities with some assumpion made in Bowers (2001). Cf. paragraph 2. for a discussion of his proposal.

internal MERGE operation (or movement). To illustrate this point, consider (12-3), an example involving wh-movement:

(12-3) [I wonder] what Gianni will say.

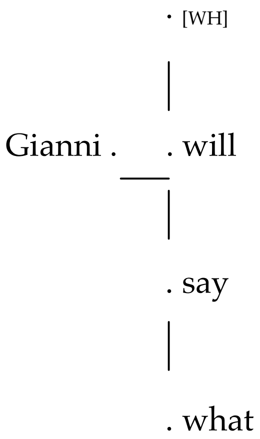
The bare phrase structure analysis of (12-3) probably could be the structure represented in (13-3)[52].

(13-3)



With a graph theoretic representation, (12-3) would have a structure like (14-3) before the internal MERGE of the item *what*:

(14-3)



V={[WH], will, Gianni, say, what}

[52] Note that the *v*P structure and the movement (internal merge) of the subject/object are ignored here.

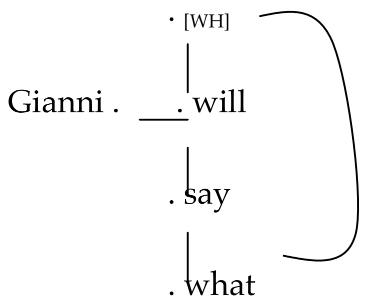
E={<say, what>,<will, say>,<will, Gianni>,<[WH], will>}

MERGE {G, G} will produce (15-3), where the wh-checking relation of <[WH], what> is inserted:

(15-3) MERGE (G, G)=G′=(V′, E′):

a.
V′=V ∪ V=V={[WH], will, Gianni, say, what}
E′=E ∪ E ∪ {<[WH], what>}={<say, what>,<will, say>,
<will, Gianni>, <[WH], will>, <[WH], what>}

b.



The representation given in (15-3) clearly violates one of the defining properties of tree from a classic perspective, (see c2): *what* is immediately dominated by *say* and [WH] (cf. also Chen-Main (2006) proposal, reviewed below in paragraph 3.9.3). More generally, internal MERGE on a tree always introduces one closed route, and the result is not a tree by definition (this fact has been noted for first by Yasui, 2004a).

The example (15-3) might look too outrageous, given the widely accepted view that a sentence has a tree structure. Nothing, however, seems to be wrong with this kind of representation as a syntactic structure.

We may ask if every lexical item has a “vertex” nature. We will address this question in Chapter 4 and 5.

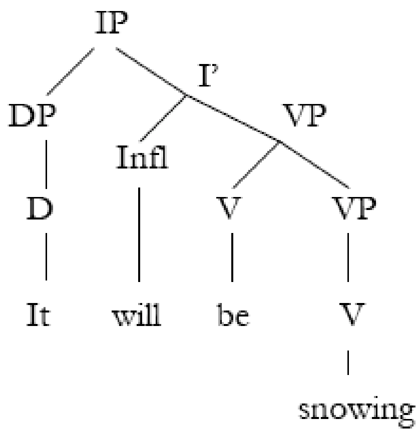
In brief, I have argued that internal MERGE is not different from external MERGE in adding one ordered pair to *E*. The difference is that in external MERGE, one member of a pair is a new lexical item introduced from the lexicon, while two of the lexical items already introduced form a pair in internal MERGE.

3.4 Constituency

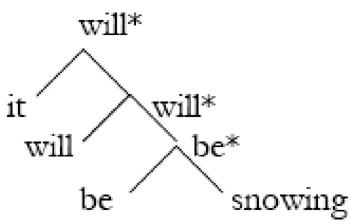
I believe that lexical graphs can capture constituency and other important syntactic relations expressed in standard tree representations. Take again (1-3) for example. Its traditional and minimalist representations are showed in (16-3 a,b), while its lexical graph is (16-3c).

(16-3)

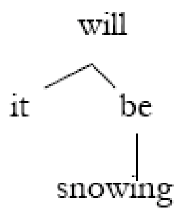
a



b.



c.



The non-branching nodes in (16-3a) are eliminated in (16-3b), and the remaining projection nodes are represented by lexical items as labels, which are marked to distinguish them from those that have a phonetic realization.

The node *be** expresses important syntactic relations: *be* and *snowing* are sisters; they form a constituent; and the constituent they form is the same type as *be* rather than *snowing*. The lower *will** has a similar function. The upper *will** captures the fact that *it* forms a larger structure with the constituent that is of the same type as *will*, and that the resultant structure is also the same type as *will*. The marked vertexes are removed in (5c), where the *relations* of selection and agreement are represented by directed edges.

The four nodes in (16-3c) correspond to the four minimal projections in (16-3b). The upper will* and be* in (16-3b) correspond to the subgraphs rooted by *will* and *be* in (16-3c), respectively. More generally, a constituent of the type α can be defined as α itself or a sub-graph that consists of all the nodes α dominates. One constituent that falls out of this definition is the lower *will** in (16-3b), which corresponds to the intermediate projection I′ in (16-3a).

This is a welcome result, since an intermediate projection is syntactically and semantically invisible as Chomsky (1994:10) claims.

Head-movement, which is strictly local, affects two nodes connected by a single edge. In a lexical graph, the subject is adjacent to the Infl just like the object is adjacent to the verb.

Assuming the standard tree representation like (16-3a), Kayne (1984) and Haegeman (1996: 485) argue that cliticization of the object to the verb is upward and syntactic, but cliticization of the subject to the Infl is downward due to the intermediate node I′ and hence must be analyzed as a PF-operation. If a lexical graph is adopted, this conclusion can be circumvented since the problematic intermediate node I′ is absent, as discussed above (cf. also Yasui, 2004a).

The configuration of a lexical graph alone does not distinguish a specifier from a complement. If syntactic structure is built first by satisfying selectional requirements, followed by agreement or formal feature checking, a specifier and a complement can be distinguished based on their derivational histories.

Alternatively, a specifier, if it is not an expletive, results from Move or internal Merge; it is connected into the category selecting it and also to the one inducing agreement with it. I will assume that a specifier can be identified by its derivational history or its double connectedness in a lexical graph.

I think that it is possible to give a basic condition for derivational steps:

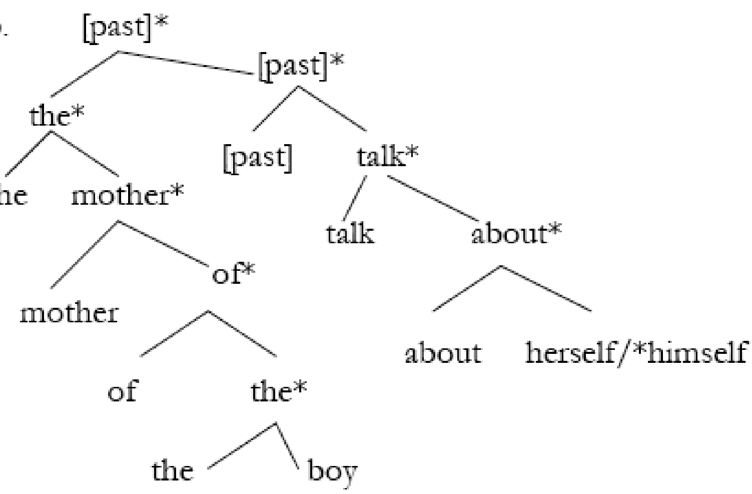
A derivation graph for an expression is a record of one possible sequence of steps taken to derive the expression in question from lexical items.

3.5 Graph theory and C-command

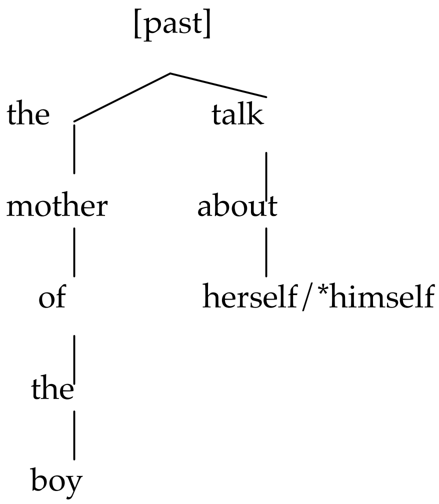
Next, consider how c-command can be defined in a lexical graph. The example in (17-3a; adapted from Yasui 2004a, who discusses the same argument in a slightly different manner) shows a typical contrast in reflexive binding, and its bare phrase structure and lexical graph are (17-3b,c), respectively.

(17-3) a. the mother of the boy talked about herfelf/*himself

b.



c.



In (17-3b), the upper *the** is immediately dominated by the root, which dominates the reflexive, but the lower *the** is immediately dominated by of*, which does not dominate the reflexive. Applying the same definition of c-command to (17-3c) can account for the contrast; the upper *the* c-commands the object but the lower *the* does not.

Note that in the subject of (17-3b), the upper *the* c-commands *of*, the lower *the* and *boy*, while it is not the case in (17-3c). Long-distance binding, holding between phrases, is attested in many languages, but heads are unknown to be related non-locally.

This supports a graph theoretic account: *a head fails to c-command distant heads within its complement.*

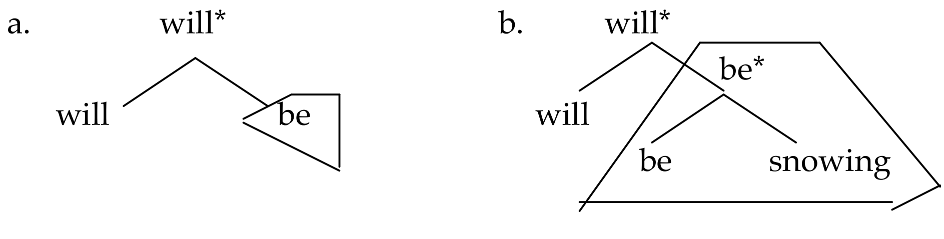
3.6 On Projection Labels

Earlier theories assumed syntactic structure to be built up in a top-down manner by rewriting rules, followed by lexical insertion. A bottom-up structure building is adopted in the bare phrase structure theory (Cf. Chomsky 1994). Phillips (2003), instead, proposes an incremental structure building, which is a kind of top-down system[53].

The presence of these conflicting proposals on the order of structure building might suggest that the selectional/agreement requirements of lexical items can be satisfied in any order (cf. also Bowers, 2001). This conclusion is acceptable to the approach sketched above but would be problematic if constituency is expressed by projection nodes (Yasui, 2004b). Going back to (1-3), the four lexical items are originally unconnected.

Remember that a *connected graph* is formed by establishing an edge between those items (vertexes) in a selection (or agreement) relation (cf. paragraph 2.2 and Bowers (2001), resumed in 3.9.2). For example, *be* is connected to *will*, which selects a bare verbal form, *snowing* is connected to *be*, which selects a progressive verbal form, and the expletive *it* is finally connected to *will*, which agrees with a nominative DP. This order would cause a violation of *cyclicity* in the traditional and bare phrase structure theory, as illustrated below:

(18-3)



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[53] Cf. also Chesi C., 2007 for another top-down inspired account.

(18-3a) is not problematic at all, but adding *snowing* results in replacing *be* in (18-3a) with the graph rooted by *be** in (18-3b). To avoid this, Frampton and Gutmann (1999, 2000) propose that a syntactic derivation should start by introducing a lexical item that selects nothing first; *snowing* in the case of (1-3). This stipulation is not necessary in the formation of lexical graphs[54].

3.7 PF-interpretation of syntactic graphs

The PF-interpretation of a standard syntactic tree is obtained by ignoring its non-terminal nodes and pronouncing its terminal nodes from left to right, and the ordering of terminal nodes comes from a value of the head parameter set for the language in question. Obviously, a lexical graph requires a different PF-interpretive algorithm, since in my opinion all its nodes need to be pronounced.

The following discussion is based on Yasui Miyoko (2004a,b) which proposes to regard syntactic structure as consisting solely of lexical items (or terminal vertexes) and to consider PF-interpretations as deduced according to a modified versions of *depth-priority tree traversal algorithms* (cf Chapter two) which apply to a given graph and yield more than one ordering of its nodes) studied in graph theory. Then, her proposal that use traversal algorithms to account for the existence of SVO vs. SOV word order will be reviewed in paragraph 3.8. An essential note is that the proposal of Yasui Miyoko is the only other graph inspired work I am aware of in the generative paradigm.

Lexical items are introduced into a syntactic derivation one by one, producing a larger structure in a bottom-up fashion according to cyclicity. Frampton and Gutmann (1999, 2000) make this fact clear in their theory of *crash-proof computation*: lexical items are introduced *automatically* in the right order, and no crash caused by incorrect order of selection is possible (cf. also Bowers, 2001). Then, it is natural to expect the right order of structure building to be reflected in the PF word order.

Their theory here can be summarized as follows:

(i) Each step of structure-building is triggered by the introduction of a new head.

(ii) If the new head is subject to selectional/agreement

[54] If a specifier is identified by its derivational history, selectional requirements must be satisfied before agreement requirements (cf also Frampton and Guttman 1999; Bowers, 2001).

requirements, some of them must be satisfied immediately in its entry to the derivation before another lexical item is introduced.

(iii) Selection takes priority to agreement.

It follows from Frampton and Gutmann considerations that only a lexical item that selects nothing can start the derivation; if a lexical item that selects a complement were introduced first, its selectional requirement could never be satisfied by itself and no other lexical items could be subsequently introduced.

Take again the example in (6-3) repeated in (19-3) and adapted from Yasui (2004a).

(19-3)
V={it, will, be, snowing}
E={<will, it>, <will, be>, <be, snowing>}

V corresponds to the initial lexical array. The ordered pairs in E express the *selectional* and *agreement* relations[55].

V in (19-3) contains four lexical items. *Snowing* selects nothing and thus can start the derivation. The next item to be introduced is necessarily *be*, which selects a progressive verb.

The third item is the modal *will*, which selects a bare verbal form. Lastly, the agreement requirement of will is satisfied by merging it with the expletive *it*. Suppose the four lexical items are indexed in ascending order as they are introduced into the derivation.

Replacing the lexical items in V and E in (19-3) with their indices results in (20-3):

(20-3)

V={0, 1, 2, 3}
E={<1, 0>, <2, 1>, <2, 3>}

The content of each node being: 0=snowing, 1=be, 2=will, and 3=it.

[55] Note that the conception of syntactic structure as a pair of V and E best satisfies the Inclusiveness Condition in that E is formed solely by set-theoretic operations on the initial lexical array, which is V.

The PF-interpretation of (20-3) can be obtained simply by putting the nodes in the descending order of their indices[56]. In other words, the "last-in-first-out" pronunciation of the stack of the lexical items can yield the Specifier Head Complement order in the case of the example in (20-3)[57].

According to Kayne's (1994) theory, a Specifier precedes head and complement since some non-terminal node dominating the former asymmetrically c-commands some non-terminal nodes dominating the latter.

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[56] This possibility avoids at all computational complexity.

[57] Frampton and Gutmann illustrate their theory with the sentence in (i), which involves movement:

(i) Men arrived.

The example in (i) consists of three lexical items: men, [past], and arrive. Arrive selects nominal, [past] selects verbal and agrees with nominal, and men selects nothing. As argued by Framton and Gutmann, men is the first lexical item to be introduced into the derivation. Men can be selected by the verb arrive and it can agree with the tense [past]. Then, given their principle "*Selection takes priority to agreement*", [past] cannot agree with men before satisfying its selectional requirement. Thus, arrive is to be introduced next as a head selecting men. The remaining lexical item is [past], and it can select arrive and agree with men. The item [past] is introduced as a head selecting arrive.

The structure constructed so far is as follows:

(ii) V={0, 1,2}	2 ([past])
	|
E={<1,0>,<2,1>}	1 (arrive)
	|
0=men,1=arrive, 2=[past]	0 (men)

All the three nodes have been indexed. Finally, the agreement requirement of [past] is satisfied by its internal Merge with men.

Suppose now that the ordered pair <2,0> is just added to E as in (iii):

(iii) V={0, 1,2}	2 ([past])
	|
E={<1,0>,<2,1>, <2,0>}	1 (arrive)
	|
0=men,1=arrive, 2=[past]	0 (men)

Pronouncing the nodes in the descending order of their indices will yield the incorrect order: [past]-arrive-men. What is problematic with (iii) is that addition of the edge <2,0> does not alter the index of men, which remains to be 0, though it is the last element affected. The bottom-up structure building can be naturally expressed by updating the index of men to 3 and adding <2,3> to E as follows:

(iv) V={1,2, 3}	2 ([past])
E={<1,3>,<2,1>, <2,3>}	1 (arrive)
1=arrive, 2=[past], 3=men-Nom	3 Ø (men-Nom)

The first ordered pair in E of (ii) is <0,1>, and it is replaced by <1,3> in (iv) (cf. Yasui, 2004b).

The proposal outlined in this section offers an alternative account: lexical items are indexed in ascending order as they are introduced into or affected in the syntactic derivation and the Specifier-Head-Complement order simply reflects the indexing (I suppose that it is a simple yet functional point of view and I am indebted with Yasui (2004a, b) for its formulation)). This conception of word order, however, is maybe too simple to capture the word order flexibility of head-final languages (Persian is a clear *ambiguous* example; cf. Chapter 4).

I will, therefore, turn to more sophisticated algorithms, which fall under *traversal* of graphs, on the lines of Yasui (2004a), who tries to give an elegant explanation of the Head Parameter.

3.8 Graph traversals (Yasui, 2004a)

Graph traversal algorithms can be classified into two major categories: *depth-priority* (i.e. *Depth first search*) and *width-priority* (i.e. *Breadth first search*) traversals (cf. Yasui, 2004a,b; Diestel, 2005 and paragraph 2.3). What seems to be relevant to the *traversal* of natural languages is the former: starting from the root, we go as deep as possible until reaching some leaf node, typically the leftmost one; we move back to its mother node and visit the other children if any; the remaining nodes are traversed in the same manner (cf. paragraph 2.3).

A depth-priority traversal starts from the root; it goes as deep as possible until reaching some leaf node, giving priority at a branching node to some of its child nodes, typically the leftmost one; it comes back to the branching node and traverses the other children nodes if any; the remaining nodes are traversed recursively in the same manner.

In all natural languages, a tree is traversed in the same way, but its nodes are pronounced in different orders. Yasui (2004b: 10) adopts these *pronunciation conditions* for graphs defined as *in-order* and *post-order* traversals[58]:

(21-3)

a. *In-order* (SVO): Pronounce a given node when it does not immediately dominate an unpronounced specifier node.

b. *Post-order* (SOV): Pronounce a given node when it does not immediately

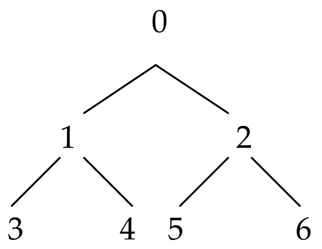
[58] A Pre-order traversal is also possible: *Pronounce a given node before its left child and right child are visited* (cf. Diesel, 2005), but Yasui consider it as marginal in the study of natural languages.

dominate unpronounced nodes.

The postulations in (21-3a,b) presuppose that a specifier is distinguishable in a lexical graph. I think that (21-3a) substantially says that a head is pronounced after its specifier and before its complement, while (21-3b) says that a head is pronounced after both of them. Anyway, I think that it will be a better solution the one who tries to go beyond the notions of specifier and complement in syntax.

A binary-branching tree in (22-3) will illustrate, however, how things work in Yasui's paradigm:

(22-3)



The left and right child of each node are its specifier and complement. Traversing (22-3) according to (21-3a,b) results in (23-3a,b), where each node is pronounced in the underlined position (the following example is a rearrangement from Yasui (2004b ; p. 11).

(23-3) a. 0-1-3 -1-4-1-0-2-5-2-6-2-0
b. 0-1-3-1-4-1-0-2-5-2-6-2-0

Traversing for example (6-3) or (17-3c) in accordance with Yasui (see again (21-3a)) produces the sequences of traversed nodes in (18a,b), respectively.

(24-3)
a. will-it-will-be-snowing
b.[past]-the-mother-of-the-boy-the-of-mother-the-[past]-talk-about-herself

If the predicate-internal subject analysis is taken, there should be one more directed edge from *talk* to the upper *the* in (17-3c). Pronouncing the subject twice can be avoided by applying (21-3a) only to unpronounced nodes.

In my opinion, the very interesting thing in Yasui account[59] is the demonstration that one way to derive multiple PF-interpretations is to choose at a branching node either of its child nodes rather than always giving priority to its left child, while another possibility is to start a post-order traversal from any leaf node and proceed towards the root generally in the ascending order of the nodes. This is reasonable since all the leaf nodes are pronounced before the internal nodes in post-order.

The *root* of a graph is unique in dominating all the other vertexes and that *leaf* vertexes are also unique in the opposite sense; they dominate no other nodes. If a post-order traversal starts from a leaf node, there should be as many head-final pronunciations as the number of leaf nodes.

3.9 Other *leading* hypothesis for a label-free syntax

I introduce in this paragraph other influential theoretical issues regarding a label-free syntax, such as the ones developed by Chris Collins (2001; 2002), John Bowers (2001), and Joan Chen-Main (2006). I have to admit that the major influence for the development of my graph-based label(and level)-free syntax has been Chris Collins' (2002) seminal paper "Eliminating labels"-

3.9.1 Collins (2001-2002): eliminating labels and projections

The main point of Collins' analysis is to suggest that it may be possible to eliminate labels in the minimalist framework. In other words, the operation Merge(V, X) yelds (b) rather than (a):

(25-3)
a. Merge (V, X) = {V, {V,X}}
b. Merge (V, X) = {V, X}

This is also the basic assumption of my work. Collins argues that given a principle of lexical access (Chomsky 2000) that he calls "The Locus Principle", the labels in the theory of Bare Phrase Structure can be eliminated entirely, leaving bare Merge as the only operation of syntax apart from Agree.

Here is Collins' Locus Principle:

(26-3)

[59] It is interesting to notice that she also developed a C++ program for the derivation of lexical graphs (cf. Yasui 2003).

"Let X be a lexical item that has one or more probe selectors. Suppose X is chosen froma lexical array and introduced into the derivation. Then the probe/selectior of X must be satisfied before any new unsaturated lexical items are chosen from the lexical array. Let us call X the locus of the derivation". (Collins 2002: 46)

Following Collins' terminology, a lexical item is said to be *saturated* if all of its selectors have been satisfied and *unsaturated* if one or more of them is still unsatisfied.

When all the selectors of every lexical item in the *array* have been satisfied, the lexical array is saturated and the process of forming relations is complete. If any selector of any lexical item has not been satisfied, then the lexical array is unsaturated and the process of forming relations is incomplete. It is possibly to assume that when a selector of a lexical item has been satisfied, it is deleted from the lexical entry. A saturated lexical item thus contains no selectors, while an unsaturated lexical item contains at least one unsatisfied selector.

The Locus Principle ensures that no relation can be formed between a lexical item and another unsaturated lexical item.

Then, Collins attempts to extend the *Minimal Link Condition* to subcategorization in a label-free theory of Merge. One straightforward way to state the Minimal Link Condition is as follows (see Chomsky, 2002 and Rizzi, 1990):

(27-3) *Let P be a probe. Then, the goal G is the closest feature that can enter into an agreement relation with P.*

Collins proposes to account for the fact that subcategorization/selection conditions are severely constrained to apply to the nearest c-commanded category of the appropriate type by treating the subcategorization/selection feature as a kind of *probe,* hence subject to the Minimal Link Condition (MLC); in order to explain the fact that the functional projection in an example such as the following doesn't block subcategorization:

(28-3) John looks too happy to leave.

Collins stipulates that the MLC applies to subcategorization in such a way that it is blocked he stipulates that the MLC applies to sub-categorization in such a way that it is blocked just in case there is an intervening lexical category ([+/-V, +/-N]). The problem is why a prenominal adjective doesn't block selection of N by a D element such as *the*:

(29-3) a. [the [smart [student]]]
b. [the [very smart [student]]]

Considering that this is not a problem in the case of a branching AP such as *very smart* in (29-3b), Collins speculates (following Rubin, 1996) that perhaps prenominal adjectives are always branching categories, though he doesn't really argue very strongly for such an approach.

In any case, it is clear that Rubin's theory, while introducing a new functional category *Mod* which selects AdvP and AP complements, is just another means of getting around the fact that X'-theory doesn't provide a natural way of distinguishing *modification* from relations such as subcategorization and selection (cf. also Bowers, 2001).

3.9.2 A basic operation for syntax: *Form Rel.* (Bowers, 2001)

In an influential yet still unpublished paper (book?) from 2001 John Bowers tries to show that the only operation needed in the syntax is "Form Relation" (*FormRel*), which combines pairs of lexical items, or features of lexical item, and forms ordered pairs in accordance with specific properties of those lexical items. Thus, Bowers argues that there is a very small set of ordered pairs that constitute the fundamental *relations* (in the mathematical sense) of natural language syntax.

Bowers, following Collins (2001; 2002) assumes in his work just four basic linguistic relations: *selection*, *subcategorization*, *modification*, and *agreement*.

In addition, the author argues that each time an ordered pair is formed, there is an immediate reflex in both at the phonological interface and the semantic interface (with principles called "Immediate Spell-Out" and "Immediate Interpretation," respectively).

Given these assumptions, Bowers tries to show that the notions of constituent structure (and so the tree adjoining model) and movement are simply artefacts of the fundamental legibility conditions that hold at the semantic and phonological levels, together with a small number of computational principles that either limit the search space of *FormRel* or limit the possible outputs of Spell-Out and Interpretation[60].

[60] Neither the idea that the primitives of syntactic theory should be *relations* rather than *constituents* nor the idea that Spell-Out and Interpretation should be immediate are totally new and unique to Bowers' theory. Various similar proposals have been shared in

Bowers assumes, as mentioned above, that there is just one basic operation in narrow syntax, *Form Relation* (*FormRel*). FormRel is a binary operation that applies to lexical items *a* and *b* and forms an ordered pair (*a, b*).

Given this operation, a network of syntactic relations is built up in the following way. First, an array *A* of lexical items is chosen from the Lexicon. Second, *FormRel* applies successively to pairs of lexical items, selected from *A* and from previously formed ordered pairs, continuing until all the selection and subcategorization (cf. Collins, 2002) features of every lexical items are satisfied and none are left unsatisfied (cf. Bowers, 2001: 16).

The derivation in Bowers' paper is regulated by the following computational principle, a slightly modified version of Collins' (2003) *Locus Principle* (see above (26-3)):

(30-3) The Locus Principle *according to* Bowers:

"Suppose a lexical item *l*, called the Locus, containing unsatisfied selection and subcategorization features, is selected from a lexical array. Then all the subcategorization conditions and selectional requirements of *l* must be satisfied before a new lexical item can be selected as the Locus" (Bowers, 2001: 18).

Bowers agrees with Collins, considering the fact that for him a lexical item all of whose sub-categorization conditions and selectors have been satisfied is said to be *saturated*; if any of them have not been satisfied, it is said to be *unsaturated*.

Indeed, the Locus Principle rules out the possibility of a lexical item *A* forming a relation with an unsaturated lexical item *B*[61].

I give an example below to make clearer Bowers' view. Consider the phrase *read the books*. The Locus Principle requires that the relation selection *RSel* (the, books) be established before the relation subcategorization *RSub* (read, the). If the latter was formed first, the Locus Principle would be violated, since the item *the* would be unsaturated (cf. Collins, 2002) at that point[62].

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frameworks such as Perlmutter and Postal Relational Grammar (see Appendix B).

[61] As shown in Collins and Ura 2001, this imposes an inherent order on the process of forming a network of relations between lexical items.

[62] It is important to note that there are no constituents in a theory of this sort. In the example just discussed, there is no constituent [the book] in narrow syntax, nor is there one of the form [read [the books]] (with or without labels). Instead, there are simply two relations (read, the) and (the, books).

From a theoretical point of view, it's interesting to say that, though there is a superficial similarity between an account based purely on relations and one that incorporates the operation Merge or its equivalent, due to the fact that both involve the construction of sets, it must be said the operation Merge goes far beyond what is involved in a *relational theory*. In the sentence above, the output of the (canonical) Merge operation would be a new syntactic object of the form: {read, {the, books}}.

Despite the fact that the outputs of successive applications of Merge are only *unordered* sets, each operation results in a new syntactic object which incorporates the results of all the preceding operations: it is clearly a theory that incorporates a notion of *constituent* structure.

In the relational theory of John Bowers, on the other hand, no new syntactic objects of this sort are produced. Instead, still considering the sentence above, there are just the two ordered pairs (read, the) and (the, books).

Bowers' account would be a *revolutionary* one, but I suppose that the notion of (a simplified) Merge is an axiom of syntactic theory[63], and I have cited Bowers' paper in my work mainly because is another important attempt to eliminate labels and to simplify the whole syntactic derivation process.

Indeed, Bowers gives a simple and economical account of the possible linearization process in syntax (Bowers, 2001; p.27):

(31-3) "Suppose *a* and *b* are lexical items and the ordered pair (a, b) is a member of the selection relation *RSel*. The linearization function (FL) operates on RSel(a,b) as follows:

FL (RSel(a, b)) = a-b".

Thus Bowers' FL is a very simple and general function which ensures that the phonetic form of the "first coordinate" of a sub-categorization relation precedes the phonetic form of the "second coordinate".

Here is an example to see how FL works. Let's start by choosing from the lexicon the items *read*, *the*, and *book*. Assuming that *the* selects nouns and *read* subcategorizes determiners, the two relations (*the, books*) and (*read, the*) can be

[63] The syntactic operation Move could *dissolve* into the simpler, more economic, and indispensable syntactic operation Merge in the simplified way shown in paragraph 3.3, and X-bar theory could be simplified from a graph theoretical point of view; in my idea of syntax, Merge is a necessary "linking operation" over two graphs, with an ordered pair added to the linking process and, in many respects I agree with Starke (2001) over the unnecessarily of operation Move by the fact that Move requires Merge, but not vice versa.

formed. The Locus Principle, in the form of Bowers, requires that they are formed in that order. The relation (read, the) couldn't be formed first, because *the* would be unsaturated at that point. Here is a *schemata* of the process, which is a simplified version of the one in Bowers (2001: 29)

(32-3) Bowers' linearization process

i)
a. Select *the*, *books* from *A* [Locus] > *the* (unsaturated); *books* is saturated.
b. *FormRel*(the, books)=(the, books) : FL((the, books))= *the-books*

ii)
a. Select *read* from *A*; select *the* from (the, books) formed at step ib) [Locus] > *read* (unsaturated); *the* is saturated.
b. *FormRel*(read, the)=(read, the) : FL((read, the)) =the-books-read

3.9.3 Multi-dominance and Lexical graphs (Chen-Main, 2006)

Finally, concerning *linearization*, I discuss briefly some of the things put in evidence by Chen-Main PhD dissertation (2006), that explores formal and linguistic consequences in a "multi-dominance" system that result from taking *linearizability* to be a property of well-formed syntactic structures.

Her work is another *intentional* return to the notion that syntactic structures should be represented at the most basic level with *nodes* (vertexes) and *edges*, and an invitation to import useful ideas and results from the study of graphs.

For Chen-Main, the point of departure is the consideration of how some common constructions such as *wh*-questions and coordinated constructions seem to allow lexical items to play *multiple* grammatical roles typically associated with distinct positions. As a prototypical example, in sentences like *"What did Gianni eat?"*, *what* is usually assumed to function as the object of *eat,* even though it appears sentence initially rather than in the canonical object position.

In another Chen-Main example *"Joe bakes and Sam sells cookies"*, a single noun phrase, *cookies*, satisfies *both* verbs' need for an object. Traditionally, this apparent "multiple-linking" is attributed to *co-indexing* distinct elements filling multiple positions, only one of which is pronounced.

Alternatively, Chen-Main argue that a *multiply-linked* element can be conceptualized as an element immediately dominated by *multiple* parent nodes. Under such a *multi-dominance* approach, trees no longer suffice for representing the immediate dominance relation. Rather, the set of syntactic structures is expanded to include *non-tree graphs* in a shape similar to those examples I have given in sections 3.2 and 3.3.

The interesting fact about Chen-Main thesis is to examine how such multi-dominance structures[64] are generated and how their terminals are *linearized*. That question is answered in her work by adopting the *node-contraction* operation, originally introduced into the Tree Adjoining Grammar formalism to allow for coordination (cf. also Citko, 2005). Chen-Main considers node-contraction to be a general mechanism in the Tree grammar system.

Here is my schematic resume of her proposal: node-contraction is involved not only in generating coordination, but also for cases traditionally dealt with via movement. The existence of island effects that prohibit movement from certain domains indicates that one must specify when multi-dominance cannot occur (by placing certain locality restrictions on node contraction at the derivational level, Chen-Main argues that a number of these island effects can be derived).

The linearization quest is a matter of real interest (cf. Obsviously Kayne, 1994 and Chapter 5) and, as I have already mentioned, shares some similarities with my approach[65]. This proposal too leaves behind the one-parent-per-node restriction that characterizes trees (nodes are allowed to be immediately dominated by multiple parent nodes), but it differs from my view in the fact that the possibility of the elimination of labels is not considered there.

Below, in (33-3) I show Chen-Main definition of a lexical graph:

---

[64] To summarize the matter, multi-dominance has been explored by a number of researchers: Peters and Ritchie's (1981) "phrase linking grammar" is a variety of multi-dominance syntax in which two types of immediate dominance are possible and a node is allowed to have a parent in both relations. The structures used by Goodall (1987) to analyze coordination allow a single lexical item to be part of multiple conjuncts. Later, Gärtner's (1997) close examination of the widely followed Minimalist Program (Chomsky 1995) led to a proposal to replace the operations *Merge*, which combines two syntactic objects and forms a single combined object, and *Move*, which duplicates part of a syntactic object and merges it with the original object, with a single hybrid operation whose application allowed multi-dominated structures. In 2001, both Starke and Chomsky recast Move as a special case of Merge. Starke (2001) argued that Move could be reduced to a special case of Merge applied to non-adjacent nodes, and Chomsky (2001) introduced the terms *External Merge*, which merges nodes that have not been merged before, and *Internal Merge*, which re-merges a node that has previously been merged, resulting in multiply dominated nodes. (see also Citko, 2005).

[65] However, the proposed process for deriving ordering information does not guarantee a linearization of terminals for every graph. A graph may be *unlinearizable* due to either lack of ordering information or *conflicting ordering* information (for a detailed account cf. Chen-Main, 2006; p. 56-62)

(33-3) *Definition of a syntactic graph* (Chen-Main, 2006; p. 53)

A syntactic graph is a five-tuple <*N, Q, ID, SP, L*>, where

N is a finite set, the set of nodes,

Q is a finite set, the set of labels,

ID is an irreflexive, intransitive, asymmetric relation in $N \times N$, the immediate dominance relation

SP is an irreflexive, intransitive, asymmetric relation in $N \times N$, the sister precedence relation

L is a function from *N* into *Q*, the labelling function, and such that the following conditions hold:

a. *Single Root Condition*
$\exists X \in \mathbf{N}$ such that
$\forall Y \in \mathbf{N}, (X, Y) \in ID^*$

b. *Non-Overlapping Condition*
$\forall X, Y \in \mathbf{N}$,
i. if $(X, Y) \in ID$, then $(X, Y) \notin SP$, and
ii. if $(X, Y) \in SP$, then $(X, Y) \notin ID$.

c. *Acyclicity Condition*[66]
$\forall X, Y \in \mathbf{N}$,
if $(X, Y) \in ID^+$, then $(Y, X) \notin ID^+$.

A corollary of this definition given is that syntactic trees could be considered as special cases of graphs. They are subject to an additional condition that avoid from not *linearized* structures.

(34-3) *Single Parent Condition* for syntactic trees (based on Chen Main

[66] Note that Chen-Main acyclity condition is a crucial point of departure from my proposal (cf. Paragraph 3.2; 3.3).

definition of a syntactic graph see above (33-3))

$\forall$X, Y, Z $\in$ **N**,
if (X $\neq$ Y)
then $\neg$ (((X, Z) $\in$ ID) and ((Y, Z) $\in$ ID))

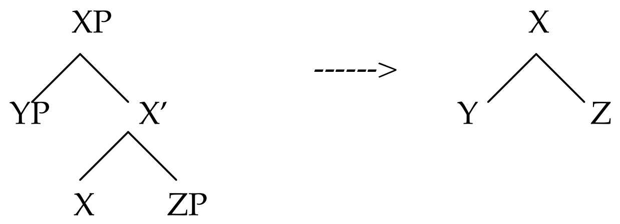
Resuming all these argument in just two words we may say that Chen-Main (2006) is another interesting proposal that considers syntactic structures as *directed graphs* that meet certain *well-formedness* conditions, and that these conditions allow some *non-tree* syntactic structures.

3.10 Another way to simplify things: Mirror Theory (Brody, 1997)

Mirror Theory is a syntactic framework developed in (Brody, 1997), where it is offered as a consequence of eliminating purported *redundancies* in Chomsky's minimalism (Chomsky, 1995). A fundamental feature of Mirror Theory is its requirement that the syntactic head-complement relation mirror certain morphological relations (such as *constituency*).

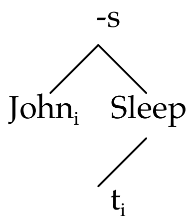
This requirement constrains the types of syntactic structures that can express a given phrase; the morphological constituency of the phrase determines part of the syntactic constituency, thereby ruling out other, weakly equivalent, *alternatives*. Another fundamental feature of Brody (1997) is the elimination of phrasal projection. Thus the X-bar structure on the left becomes the mirror theoretic structure on the right:

(35-3)



(Brody, 1997) calls this systematic collapse of X, X' and XP nodes "*telescope*". Every node may now have phonetic content, and children are identified as specifiers or complements depending on their direction of branching; left-daughters are specifiers and right-daughters are complements (previously, as we know specifiers were children of XP, and complements were children of X'). Furthermore, the complement relation is a "word-forming" relation, where according to the "mirroring" relation, the phonetic content of each head follows the phonetic content of its complement. For example, mirror theory can generate trees like the following, which given the "mirror" relation between morphology and syntax, is pronounced *John sleep - s*:

(36-3)



Kobele *et al.* 2002 in a work based on Joshi (1987)[67] give a formal representation of a Mirror grammar. A mirror theoretic tree can be viewed as a standard binary branching tree together with two functions; one, a function *f* from branches to a two element set {*right; left*}, the other, a function *g* from nodes to a two element set {*strong*; *weak*}. If *a* is the parent of *a'*, then *a'* is a specifier (or left child) of *a* if f ((*a*; *a'*)) = left and a complement (or right child) of *a* otherwise.

In basic terms, a mirror theoretic expression is defined to be a mirror theoretic tree along with a labelling function from the nodes of the tree to a set of labels. A label consists of a phonetic part (which is opaque to the syntax) and a finite sequence of syntactic features. A mirror theoretic grammar consists of a finite lexicon of 'basic' expressions, together with two structure building operations, *merge* and *move,* which build expressions from others either by adjoining structures, or by displacing sub-parts of structures.

Each operation in Mirror Theory is feature driven, and 'checks' features (and thus a derived expression will have fewer features than the sum total of the features of the expressions (*tokens*) used to derive it). The expressions generated by the grammar are those in the closure of the lexicon under the structure building functions.

A complete expression is one all of whose features have been checked, save for the category feature of the root, and the string language at a particular category is simply the yields of the complete expressions of that category.

[67] I frankly suggest to read Joshi, Aravind K. 1987. An Introduction to Tree Adjoining Grammars. In A. Manaster-Ramer, editor, *Mathematics of Language*. John Benjamins, Amsterdam.

4. Topics of Persian Syntax and a Graph Model for Persian Efaze-morpheme

In this section, after an introduction of some interesting issues in Persian syntax (the theme of my *tesi di laurea*), I develop a graph based account of the "Ezafe puzzle" in Western Indo-iranian languages, in which NP modifiers standardly occur postnominally and "link" to the noun head via an Ezafe particle (*Ez*), which may be invariant (Persian, Sorani), or agree with N in ϕ-features (Kurmanji, Zazaki).

4.1. A Brief Introduction to Persian Syntax

In this paragraph I review some basic aspect of Persian Syntax with major emphases on some syntactic aspects that I have already considered in previous works (cf. Franco 2004; 2006), such as Inverse Case Attraction of Persian relative clauses and *light verb* constructions which, in this language seems to be an *ouvert* instance of Hale and Keyser (1993; 2002) compositional syntactic analysis (without theta-roles) of Argument Structure (see Harley, Folli, Karimi, 2003).

4.1.1 Persian Word Order *(basics)*

Persian syntax is quite ambiguous and several factors contribute to the ambiguity. Although Persian is a verb-final language, it does not *adhere* to a strict word order and the sentential constituents may occur in various positions of the clause; this is especially the case for preposition phrases and adverbs. In addition, there are no *ouvert* markers, such as case morphology, to indicate the function of a noun phrase or, at least, its boundary; in Persian, only specific direct objects receive an overt marker (*ro*; *râ*) (Lazard, 1992; Megerdoomian, 2001; Franco, 2004). In spoken language, the Ezafe morpheme is used to *link* the elements within the noun phrase, but being a short vowel (-*e*; -*ie*), is absent in written text (Megerdoomian, 2001). Furthermore, subjects are optional in Persian and subject-verb agreement is not always present for *inanimate* subjects. Persian preposition phrases, however, are easily recognized and can be used to mark phrasal boundaries in the sentence.

Thus, Persian standard sentences appear in the word order Subject-Object-Verb[68]. The verb is marked for tense and aspect and usually agrees with the subject in person and number. Persian is a *pro-drop* language, given the fact that subjects are optional (Ghomeshi, 1997; Megerdoomian, 2001). The object marker *râ/ro* is used to indicate specific direct objects in simple sentences:

(1-4) bache-hâ panjare-râ shekast-and (Megerdoomian, 2001)
child-Plur window-Obj break-Past-3pl
"The children broke the window."

If there is an oblique object or a Prepositional Phrase in the clause, it precedes the indefinite direct object as shown in (2-4), but usually follows the specific or definite object as in (3-4)[69].

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[68] Alternate word orders, as already mentioned, are possible (Karimi, 1999):

- *Initial Position*: Almost any element, aside from adjectives, can be moved to sentence-initial position for emphasis. This includes preposing a verb for contrastive emphasis, as well as adposing various types of adverbs.

- *Final Position*: The subject may be moved to final position (after the verb) to indicate non-contrastive emphasis. Adverbs of time may also be moved to final position.

- *Clefting*: subjects, direct objects, and prepositional objects can all be clefted by moving to initial position and inserting the copula and the complementizer *ke*.

(i) Be Zohre bud ke Sima sa'aet-o dad
to Zohre was that Sima watch-OBJ gave
'It was Zohre that Sima gave the watch to.' (Mahootian: 1997: 118)

- *Topicalization*: Object noun phrases are topicalized by moving them to sentence initial position. The topicalized elements retain their object marker. Adverbs can likewise be topicalized by movement to initial position with affixation of the topic marker. (This contrasts with movement for emphasis, where the object marker is not present.) Indirect objects may be topicalized through movement and affixation of the object marker (cfr. Franco, 2004, 2006)… Otherwise, indirect objects may be topicalized through movement of the entire PP (no object marker.).

- *Dislocation*: Noun phrases can also be topicalized via dislocation to initial position together with realization of an object clitic on the verb. The left-dislocated noun phrase bears an object marker. Noun phrases can also be right dislocated, though this is uncommon (Lazard, 1992).

- *Scrambling*: pre-verbal elements may scramble freely (cf. Karimi, 1999 for details).

[69] I want to underline that, although these examples describe the "common" word order, Persian, as extensively pointed out, is (quite) a *free* word order language (cfr. Karimi, 1999; Megerdoomian, 2001) and the sentential constituents can be moved around in the clause. These "scrambled" clauses often give rise to focused or topicalized readings (Karimi, 1999). As discussed in Lazard (1992) in the written language, although most elements may appear in relatively free word order, the sentences *often* remain verb-final. Notice that, apart from manner adverbs, which occur within the verb phrase, other adverbs may appear almost anywhere in the clause, in between the various constituents, but usually cannot occur following the verb.

(2-4) Amir be bache-hâ nân dâd (Lazard, 1992)
Amir to child-Plur bread gave/3sg
"Amir gave (some) bread to the children."

(3-4) Amir nân râ be bache-hâ dâd (Lazard, 1992)
Amir bread Obj to child-Plur gave/3sg
"Amir gave the bread to the children."

Although Persian is verb-final at the sentential level, it behaves like head-initial languages in noun phrases (NP) and preposition phrases (PP). Thus, the head noun in a NP is (very often) followed by the modifiers and possessors (4-4), and the preposition precedes the complement NP (5-4).

(4-4) a. khar-e man
donkey-Ez myb,
"my donkey"

b. yek khâne-ye siah
one house-Ez black
"A black house."

(5-4) mardom dar khyâbân-hâ tazâhorât mi-kard-and
people in street-Plur demonstrations Imp-do-3pl
"People were demonstrating in the streets."
(Megerdoomian, 2001)

Furthermore, some preposition phrases, such as locative PPs, follow the verb as shown in (6-4 a;b). The preposition is sometimes optional in these cases.

(6-4) a. bache-hâ raft-and (be) manzel (Megerdoomian, 2001)
child-Plur go-Past-3pl (to) home
"The children went home"

b. pâkat-râ gozâsht ru-ye miz (Megerdoomian, 2001)
envelope Obj put-Past-3sg on-Ez table

"(He/she) put the envelope on the table".

In the Persian language subordinate clauses follow the main clause as illustrated in (7-4). Persian has the complementizer *ke* (that) which marks both subordinate constructions and relative clauses; it is often optional.

(7-4) mardom ne-mi-khâst-and (ke) Mahmud Ahmadinejad dar in entekhâbât barande shavad
people neg-*Imp*-want-Past/3pl (that) Mahmud Ahmadinejad in these elections winner become-Subj/3sg
"the population didn't want Mahmud Ahmadinejad to win in these elections"

Questions are usually formed *in-situ*: most of the times the element being questioned is replaced by the interrogative form without changing the word order (8-4).

(8-4) a. bache-hâ chi-râ shekast-and? (Megerdoomian, 2001)
child-Plur what Obj break-Past-3pl
"What did the children break?".
b. ki panjare-râ shekast? (Megerdoomian, 2001)
who window Obj break-Past-3sg
"Who broke the window?"

4.1.2 The Split-*headedness* hypothesis and Persian word order (*advanced*)

In generative terms, while Persian has a Subject Object Verb (SOV) word order it is not strongly *left-branching*. We have seen (cf. also the footnotes above) that Persian can have relatively free word order, the so called "scrambling". This is because the parts of speech are generally unambiguous, and prepositions (and the accusative marker for definite objects) help disambiguate the Case of a given noun phrase. Note that this *scrambling* characteristic (cf. Karimi, 1999) has allowed Persian a high degree of flexibility for versification and rhyming (cf. Lazard, 1992).

It should also be interesting to remark that Persian nouns have no grammatical gender and possession is expressed by special markers: if the possessor appears in the sentence after the thing possessed, the Ezafe may be used; otherwise, alternatively, a pronominal genitive enclitic is employed (es. *Sag-e man* vs. *sag-am*: my dog). Inanimate nouns pluralize with *-hā*, while animate nouns generally pluralize with -*ān*, although -*hā* is also common (cf. Dehdari, 2006).

Since the basic word order seems to be SOV[70], a *cursory* hypothesis might be that the language is *head-final*. However many evidences from other

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[70] It is useful to notice that, often, assigning languages to some basic word order can be difficult and for some free word order languages the concept of basic word order may be consider as *irrelevant* (see Dyrbal, as an example). Anyway, three major constituents (Subject, Object and Verb) are commonly assumed, so we have six logical permutations (all realized, data from M. Dryer in Comrie *et al.* 2005):

(i) John ate potatoes SVO (English)

(ii) Salomè ketab-ha mixune
Salomè book-s reads
"Salomè reads books." SOV (Persian)

(iii) Lladdodd y ddraig y dyn
killed the dragon the man
"The dragon killed the man." VSO (Welsh)

(iv) S˜u˜uy yi qawuh
howler-monkey people eat
"People eat howler monkeys." OSV (Nadeb)

(v) Nahita ny mpianatra ny vehivavy
saw the student the woman
"The woman saw the student" VOS (Malagasy)

(vi) Toto yahosie kamara
man it-grabbed-him jaguar
'The jaguar grabbed the man.' OVS (Hixkaryana)

In general, we can represent the frequency of the six basic word order types as follows (cf. Comrie *et al.* 2005):

(vii) SOV > SVO > VSO > VOS > OVS > OSV

At first glance, there is no reason for assuming a connection between basic clausal word order and the relative order of elements of the constituent of the clause. However, there exist many significant correlations. Joseph Greenberg (1963) was the first to establish the importance of *universal statements*. The universals in his pioneering paper are mainly absolute and implicational.

Universal 1 (Greenberg, 1963)

In a declarative sentence with nominal subject and object, the dominant order is almost always one in which the subject precedes the object.

Note that all of Greenberg's implicational universals are unilateral (*irreversible*).
Also consider again the fact that it has been widely assumed that head-initial languages like Italian and head-final languages like Japanese are hierarchically the same, and their contrast in word order has been described by the *head-parameter*. This accords the commonly assumed axiom that linear properties are not syntactically significant and hierarchical properties are universal. (We will try to challenge this fact in Chapter 5).

structures in the language would easily invalidate this notion. For example, prepositions precede noun phrases and nouns precede genitives and relative clauses.

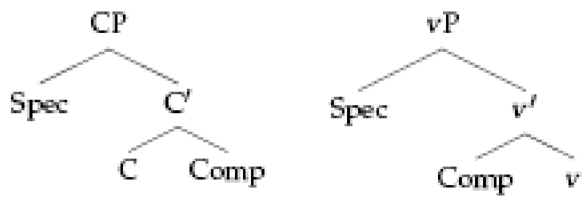
This could lead us to view Persian as *head-initial*, with the verb-object relation forming a relevant exception (Comrie, 1989: 98, 211; Mahootian, 1997: 5).

"Persian is *operand-operator* language . . . but exceptionally it has OV word order" (Comrie, 1989: 98)

An alternative to categorically classifying Persian as either head-initial or head-final is *split headedness*. Roberts (2000: 63) designates categories in Pashto (the language spoken in Afghanistan, which shares some similarities with Persian) as being either functional (*head-initial*) or lexical (*head-final*). This is a relevant *asymmetry* between functional and lexical items, and the consideration above (concerning the different status among linguistic items) will play, independently, a crucial role for the *strong graph hypothesis* that will be developed in the fifth chapter.

A similar analysis could be applied to Persian. I follow Dehdari (2006) proposing, in minimalist terms, that there is evidence for a split-headedness in Persian, where the *vP* node and lower phrases are head-final, and the CP node and lower phrases until *vP* are head-initial. Such an analysis is used by Dehdari, in his MA thesis, to economically account for *crossing dependencies* in Persian, as well as many other (seemingly) contradictory phenomena in the language. The general structure of the two phrase types is as follows:

(9-4)



It's relevant to consider that these two phrase types (CP and *v*P) correspond to the two *phases* mentioned in Chomsky (2001a). Chomsky

For example, a reflexive in object position refers to the subject, whether it follows or precedes the verb, which seems to show that the antecedent-reflexive relation is hierarchical. Many linguistis argue that a *precedence* relation is not enough.

describes phases as *self-contained components of derivation*, and asserts that internal elements of a given phase must be on its *phase's edge*, before moving out to another phase. Within a traditional paradigm, it is a *must* to describe Persian CP as head-initial, because this is an easy way to account for many facts concerning CPs in Persian:

a) complement clauses follow matrix clauses;

b) relative clauses follow matrix clauses;

c) the interrogative particles aya/magar (if) are the "topmost" items in interrogative sentences;

d) although wh-words do not necessarily move, when they move, it is to the beginning of an utterance.

See the examples below:

(10-4)

a. ne-mi-dun-e [$_{CP}$ ke farda mi-yam]
NEG-DUR-know-3S that tomorrow DUR-come-1S
'He doesn't know I'm coming tomorrow.' (Mahootian 1997: 90)

b. un mard-o [$_{CP}$ ke ruzname mi-xund] peyda kard
that man-OM that newspaper DUR-read visible did
'He found the man who was reading the newspaper.' (Mahootian 1997: 34)

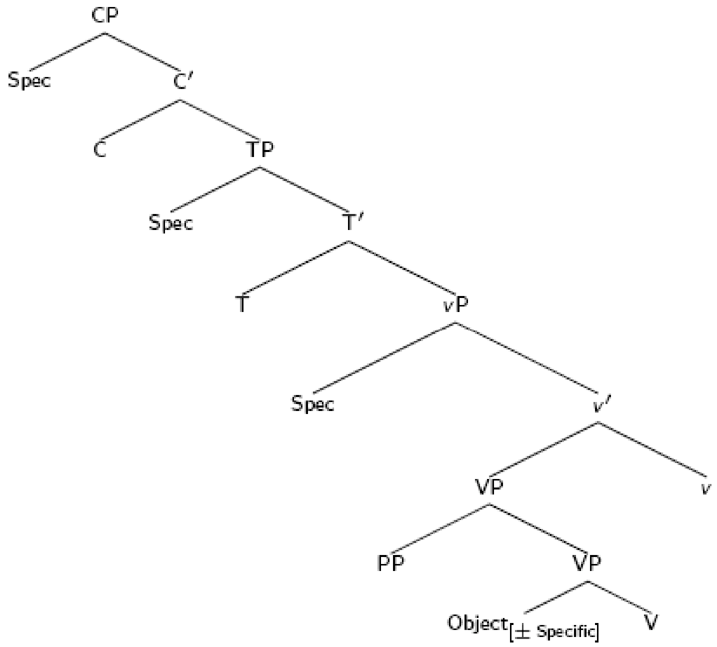
c. aya in gorbe-ye-shoma-st?
INTER this cat-Ez-you-is
'Is this your cat?' (Mahootian 1997:9)

d. cera ma saket be-man-im?
Why we quiet SBJN-remain-1P
'Why do we remain quiet?' (Dehdari 2006: 45)

Concerning *split headedness* an *implied* statement was made by Karimi (2005) assuming the following clause structure for Persian:

(Karimi, 2005: 7)

(11-4)



I propose the following table (adapting and revising the one proposed in Dehdari, 2006) to summarize the evidences given by the empirical data:

(Tab. 4-1)

Relationship	*Head initial*	*Head final*
Perf Aux - VP		√
V – manner adverb		√
V – Obj		√
Verbal Copula – Pred		√
V – PP		√
Passive Aux – V		√
Preposition – N	√	
Det – N	√	
Num – N	√	
N – Relative enclitics	√	
N – Gen (Ez)	√	
Adj – superlative (es. tarin)	√	
Complementizer – S	√	
Interrogative – S	√	
Tense (es. mi particle) – VP	√	
Adverbial Subordinator - S	√	

It would be logic to assume that human parsers are *quicker* when the branching is consistent in one direction. Mixed-branching seems hard to process. However, Persian data seems to reveal a mixed model.

Kayne (1994) challenges the above view. According to Kayne's theory, linear ordering is *mapped* from asymmetric c-command relations that hold between non-terminal nodes; thus, distinct word orderings should not reflect distinct hierarchical structures (cf. Chapter 5). Kayne (1994) argues that head final languages have a head-initial underlying structure with abstract *functional* categories, to which movement operations apply so as to derive the appareant head-final order. It is interesting to notice that Chomsky (1995) points out some weaknesses of Kayne's theory such as its crucial reliance on non-branching nodes to deduce surface order.

Another type of word order variation that is not strongly linked to clear syntactic (or semantic) differences has been referred to *scrambling,* the widespread phenomenon of Persian syntax. See the following example from Japanese, which is acceptable, without a *heavy stress* on the initial constituent or a *pause after it*:

(12-4) Mary-o John-ga mi-ta
Mary-Acc -Nom go-Past
'Mary, John saw.'

One dominant approach represented by Saito (1985) and subsequent work is to regard (12-4) as derived by the syntactic operation of *scrambling* (cf. also Karimi, 1999 for Persian data). Scrambling, in a traditional framework, produces an adjoined structure and the moved constituent leaves a *trace* in its original position. So we have to assume hierarchical properties that differ from the non-scramblel (base-generated) instance.

As we have seen in chapter 3 a syntactic graph theory allows to formulate algorithms that can deduce *multiple* PF interpretations from the shared syntactic structure.

The flexibility in word order or the multiplicity of PF interpretation appears to be attested in head-final languages (Fukui (1993); Yasui (2004)). But also head initial languages[71] have variable degrees of word order freedom.

[71] For instance, English, which is head-initial, allows a certain amount of word order freedom by shifting a heavy NP rightward as shown in (ia,b), but a light constituent like the pronoun it cannot be shifted rightward, as shown in (id):

It can be said that head-final languages allow wider variation in word order than head-initial languages, and the variation in the former is always *leftward*; *rightward* word flexibility is highly limited. Another importantasymmetry between head-initial and head-final languages was pointed out by Bresnan (1972).

Bresnan (1972: 42) states that *only languages with clause-initial Complementizer permit a Complementizer-attraction transformation*[72].

Fukui (1993) proposes a stimulating theory of the correlation between a value of the head-parameter and word order flexibility based on a grammatical operation (*Move alpha*) that creates a structure that is inconsistent with the value of a given parameter in a language is *costly* in the language, whereas one that produces a structure consistent with the parameter value is *costless* (Minimalist economy is well interpreted in this way). According to this idea, scrambling in head final languages is of no cost since it moves a constituent *leftward* and does not destroy the head-finality.

Here is Fukui's account (1993: 400):

a. A language has a costless optional movement (or shows flexible word order) only if it is head-final, and the operation produces a structure consistent with the head-final value (i.e., it is leftward).

b. A language has a costly obligatory movement only if it is head-initial, and the operation produces a structure inconsistent with the head-initial value (i.e., it is leftward).

(i)
a. They brought the beautiful dress into my room,
b. They brought into my room the beautiful dress. (Fukui (1993: 410))
c. They brought it into my room.
d. *They brought into my room it.

On the other hand, for example, Japanese scrambling moves a constituent leftward, whether it is light or heavy, as shown in (iia,b):

(ii)
a. sono utukusii doresu-o karera-wa watasi-no heya ni mottekita.
that beautiful dress-Acc they-Top I-no room to brought (Fukui (1993: 410))
b. sore-o karera-wa watasi-no heya ni mottekita.
it-Acc they-Top I-no room to brought

[72] Logically possible but non-existent would be languages with a clause-final Complementizer that attracts a wh-phrase rightward.

Crucially, it is possible to observe that in Persian *long distance scrambling* occur when involve head-final elements[73], while, interestingly, it is blocked by any intervening NP with the same case as the NP being long distance scrambled[74] (cf. Karimi, 1999: 174- 176; Richards, 2002: 240).

(13-4)a. *Sasan Kimea goft [ke _ ketab-â-ro az Sepide kharide]
Sasan Kimea said that book-Pl-Spec.Acc from Sepide bought
"Sasan, Kimea said [that _ bought the books from Sepide]"

b. *be Ali Sasan be Kimea goft [ke ketab-ro _ dâde]
to Ali Sasan to Kimea said that book- Spec.Acc gave
"To Ali, Sasan said to Kimea [that he gave the book _]

c. *dokhtar-â-ro Kimea pesar-â-ro tashvig kard [ke _ bebusand]
girl-Pl-Spec.Acc Kimea boy Pl-Spec.Acc encouragement did that kiss
"the girls, Kimea encouraged the boys [to kiss _]

[73] Following Yasui (2004a), I think that an elegant account of Persian word order may be given if we simply admit the possibility of an *algorithm shift* in the course of the derivation (cf. Chapter 3).

Indeed, the PF-interpretation of a standard syntactic tree is obtained by ignoring its non-terminal nodes and pronouncing its terminal nodes from left to right, and the ordering of terminal nodes comes from a value of the head parameter set for the language in question, while, obviously, a lexical graph requires a different (*shiftable*) PF-interpretive algorithm, since all its nodes need to be pronounced.

Does a lexical graph possess the linearity required for its PF interpretation? I claim that it originates in its overall configuration. Lexical items are introduced into a syntactic derivation one by one, producing a larger structure at every step. Frampton and Gutmann (1999, 2002) make this point clear in their theory of crash-proof computation: lexical items are introduced automatically in the right order, and no crash caused by incorrect order of selection is possible. Then, it is natural to expect the right order of structure-building to be reflected in the PF word order.

As I have already pointed out in the previous chapter, following Yasui (2004), tree traversal algorithms can be classified into two major categories: depth-priority and width-priority traversals. What seems to be relevant to traversal of natural languages is the former: starting from the root, we go as deep as possible until reaching some leaf node, typically the leftmost one (for spatial-temporal reasons); we move back to its mother node and visit the other children if any; the remaining nodes are traversed in the same manner.

[74] Notice that this facts seems to hold in Japanese as well (cf. Saito, 1985:185, cited in Richards, 2002), where scrambling of a subject past another subjest is impossible:

(i) *Sono Okasi-ga John-ga [_ oisii-to] omotteiru
this candy-Nom John-Nom tasty that thinks
"This candy, John thinks [_ is tasty]

4.1.3 Some observations on Persian relatives: a Case Attraction phenomenon

Persian relative clauses are usually introduced by the complementizer *ke* (that), which is used regardless of the animacy, gender or function of the head noun (Karimi, 2001). In non-restrictive relative clauses, the head noun often carries an enclitic morpheme (*Encl*) which links the noun to the following relative clause (14-4). If the relativized noun is the object of the main sentence, then it may appear with the object marker râ as illustrated in (15-4). That's an interesting empirical observation. The following examples are from Megerdoomian (2001).

(14-4) zan-i ke injâ neshaste ast hamsar-e Nâder ast
woman-Encl that here sit-*Part* is spouse-Ez Nader is
`The woman that is sitting here is Nader's wife"

(15-4) ketâb-i-râ ke diruz kharide budam emruz- sobh tamâm kard-am
book-Encl-Obj that yesterday bought was-1sg today-morning finish did-1sg
"This morning, I finished the book that I had bought yesterday."

The relative clause may be separated from the head noun by the main verb as illustrated below (see Megerdoomian, 2001 and Franco, 2004 for a more articulated discussion). In addition, several relative clauses could follow a head noun. The following example in taken from Ghomeshi (2002).

(16-4) mâ pesar-ân-i-râ entekhâb mi-kon-im ke dar jang sherkat na-karde-and
we boy-Plur-Encl-Obj choosing Imp-do-1pl that in war participation neg-done-3pl
"We choose (the) boys that have not participated in the war."

If the head noun is the subject or direct object of the relative clause, it is often left as a gap as was shown in the examples in (14-4) and (15-4). However, even in such cases, the relativized noun may be replaced by a *resumptive* pronoun in the clause it originated from. Thus, in (17-4), an example taken from Megerdoomian doctoral thesis (2001), the head noun *plâk-e kuchak* (small plaque) is the subject of the relative clause; it is substituted by the *resumptive* pronoun *ân* (it).

The use of the resumptive pronoun usually occurs when the head noun is separated from the relative clause by an intervening verb (cf. McCloskey, 1992). In this example, the verb *pey borde-and* (have found) precedes the relative clause.

(17-4) dâneshmand-ân be plâk-e kuchak-i dar maqz pey-borde-and ke ân niz tâkonun nâshenâxte mânde bud.
scientist-Plur to plaque-Ez small-Encl in brain found-3pl that it also until now unknown remained was
"Scientists have found a small plaque in the brain that until now had remained undiscovered".

Thus, when the head noun is the indirect object or is extracted from a Prepositional Phrase adjunct in the clause, a resumptive pronoun is used. In other words, the position from which the head noun originates is substituted by a pronoun that agrees with the head noun. This is exemplified in the sentences below:

(18-4) in bache-hâ ke az ânhâ âdres mi-porsid-i...
this kid-Plur that from them address Imp-ask-2sg
"These kids from whom you asked for the address..."

(19-4) shahr-i ke dar ân tazâhorât shode bud ...
city-Encl that in it demonstrations become was
"The city in which demonstrations took place..."

(20-4) zan-i ke barây-ash ketâb kharid-i ...
woman-Encl that for-Clitic(3sg) book buy-Past-2sg
"The woman for whom you bought a book..."

As shown in Franco (2006) and as already mentioned above (15-4), the morpheme /raa/; /ro/ in spoken form) - as the specific marker for accusative case - can accompany, at least in spoken language, the head noun of the relative clause that is the subject of the main clause and the object of the relative clause (21-4) in Persian.

(21-4) Zan-i-ro [ke did-i] inja-st

woman-Acc that saw-2sg here-is
"The woman whom you saw is here"

While this phenomenon concerning the Persian language, known in the literature as Case Attraction, resembles to the "Inverse Attraction" discussed in Bianchi (1999) for Latin and Ancient Greek, it has its own peculiar characteristics:

a) it is quite optional
b) it blocks extraposition, as shown in (22-4),
c) it is always the nominative case that is attracted to the accusative case (23-4a,b,c).

(22-4). *Zan-i-ro inja-st [ke did-i]

(23-4)
a. pesar-i-ro [ke …]
boy-Encl-obj that
NOM ⇔ ACC
b. *be pesar-i-ro [ke …]
to boy-encl-obj that
DAT ⇔ACC
c. * az pesar-i-ro [ke …]
from boy-encl -obj that
ABL ⇔ACC

Then, this attraction only applies to the head noun of the restrictive relative clause. Since the head noun of the non-restrictive clause lacks the restrictive morpheme /-i/, it cannot attract the marker for the accusative case (24-4).

(24-4) * an mard-e mosen-ro [ke diruz did-am] emruz raft
that man-EZ old-obj that yesterday saw-I today went-3sg
"That old man, whom I saw yesterday, went today".

Karimi (2001), instead, argues that /raa/,/ro/ as the specificity marker for accusative case in Persian, cannot be generated with the relative head in the relativized position (subject position of the relative clause) (25-4 a;b). Hence, rejecting Kayne's (1994) raising analysis, she suggests that the head noun is base-generated in the Spec of the *larger* DP and then it moves to the spec of KsP (the suggested projection that has the marker in its head) (26-4).

(25-4). a. Kimea un pesar-i-ro [ke inja neshaste bud] be man mosarrefi kard.
Kimea that boy-Acc that here sitting was-3sg to me Introduction do-past-3sg
"Kimea introduced to me the boy who was sitting here"

b. un… [$_{CP}$ [$_{C'}$ ke [-i pesar-ro] inja neshaste bud]]
tha that encl boy-Acc here sitting was-3sg

(26-4) [$_{ksP}$ [un-pesar-i] $_{i}$ [$_{Ks'}$ –ro] [$_{DP}$ ti [$_{D'}$] [$_{CP}$]]]
(Karimi, 2001)

Given the possibility of the occurrence of the accusative case marker /raa/ with the subject of the main clause (when is the object of the relative clause), I propose that, at some point in the computational process of derivation, the case marker /raa/; /ro/ *was* present inside the relative clause.

Adopting a raising analysis - as suggested by Kayne (1994) and discussed in Bianchi (1999) and Bhatt (2002) among others - for relative clauses in Persian we will come up with a structure as in (27-4) for sentences like the one in the example (21-4). The case marker for the accusative together with the head noun moves to the position of Spec of CP and then the head noun further moves to spec of DP.

(27-4) [$_{CP}$ [$_{DP}$ [zan] $_{K}$ –i t_{K} -ro] $_{i}$ [$_{C'}$ ke *ti* did-i] inja ast

If my proposal is right, so the empirical facts that I cited above are evidences for the possibility of a raising analysis to explain the syntax of relative clauses in Persian. The impossibility of generating the accusative marker with the head of the relative clause in a relativized subject position in Karimi (2001) appear as an inadequate argument for rejecting a raising analysis[75]: as we have shown, the appearance of the same case marker with the subject of the main clause is an important empirical observation that supports a raising analysis.

4.1.4 Persian Noun Phrases [a rough guide to *the Ezafe domain*]

The head of a noun phrase could be a noun or an infinitival verb. Pronouns and proper names may also head noun phrases and they function as possessors in forming complex noun phrases (such as possessive constructions: *ketâb-e Saloomeh* (Salome's book)).

Persian head noun is preceded (at the surface) by the determiners, the numeral constructions and the quantifiers, and it is followed by the modifiers, which usually consist of an adjectival phrase (AP). Superlative adjectives, however, do not appear in the AP; instead, they precede the head

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[75] In this note I show the basic syntactic interpretations for the two major competing analyses of relative clauses: the *raising analysis* and the *matching analyses*. The head raising analysis was originally proposed by Brame (1968), Schachter (1973), and Vergnaud (1974). Recent versions include the relevant one of Kayne (1994), among others. Under the head raising analysis that we are adopting, the head NP originates inside the relative clause CP, as shown in (i).

(i) the [book]*j* [CP [which t*j*]*i* John likes t*i*]

The matching analysis was originally proposed in Lees (1960) and Chomsky (1965) and has been discussed and extended in Sauerland (1998). The matching analysis postulates that corresponding to the external head there is an internal head which is phonologically deleted under identity with the external head. However, the internal head and the external head are not part of a movement chain. In fact Sauerland argues that in certain cases, the lexical material of the internal head does not need to be the *same* as the lexical material of the external head. It just needs to be *similar* enough.

(ii) the [book] [CP [which book]*i* John likes t*i*]

A more articulated discussion is impossible here, considering the aim of this work. Anyway, I want to show the consequences of an interesting observation made by Richard Larson (1985). Larson observed that headed relative clauses containing a trace in adjunct position, but neither a relative adverb or a stranded preposition, are grammatical only if the external head of the relative clause is a *bare-NP adverb*.

(iii) a. the way [Op*i* that you talk t*i*] (Larson, 1985, from Bhatt, 2002)
b.*the manner/fashion [Op*i* that you talk t*i*]
c. You talk that way.
d.*You talk that manner/fashion.

The well-formedness of the operator-variable chain in (iiia) depends upon what the head NP is. Information about the head NP is required internal to the relative clause. Under a head raising or a matching analysis, the ill-formedness of (iiib) directly follows from the ungrammaticality of (8d). This explanation is not directly available under the head external analysis, and Larson, who is assuming the head external analysis, has to introduce a not economical feature transmission mechanism which makes the relevant information about the head NP available *internal* to the relative clause.

noun. Numeral constructions, quantifiers and superlative adjectives are in complementary distribution: if one of these elements is present, the others cannot occur within the DP.

The modifiers are linked to the head noun with the Ezafe-morpheme[76], which is the main object of our analysis. The following example represents a typical simple Persian noun phrase. Regarding this example, it is interesting to note that, in Persian, classifiers indicate the class or type of the noun. Thus, for instance, *tâ* is used with count inanimate nouns, *nafar* indicates people, *qalâde* can be used when giving a count for dogs, donkeys or other animals.

(28-4) in do-tâ ketâb-e kohne
this two-CL book-Ez old
"These two old books."

Furthermore, the infinitive head can appear in a predicate construction (29-4) or with an adverbial.

The objects of the verb become arguments of a possessive construction as exemplified in (30-4).

(29-4) zan budan-ash
woman be-her
"her being a woman"

(30-4) koshtan-e shir (Kahnemuyipour, 2000)
kill-Ez lion
"the killing of a lion"

As already mentioned above, the element joining the Persian noun phrase constituents to each other is the Ezafe suffix. It's important to notice from the very beginning that the last constituent in the DP does not carry the Ezafe suffix, thus marking the end boundary of the phrase (31-4).

(31-4) ketâb-e dust-e pedar-e Amir
book-Ez friend-Ez father-Ez Amir

[76] This morpheme is almost always absent in written form. It does occur, however, after the vowels /â/ and /u/ as exemplified below.

(i) zan *zibâ-ye* dâryush vâred shod (*written Persian*: Lazard, 1992)
wife beautiful-Ez Dariush entered
`Dariush's beautiful wife entered.'

"Amir's father's friend's book."

When pronouns are used as the possessor, the constructions are identical, as in (32-4):

(32-4) ketâb-e man
book-Ez 1sg-pronoun
"My book."

Then, we introduce that certain morphemes, such as the pronominal clitics, the indefinite article and the enclitic used to link NPs to relative clauses (cfr. 4.1.3), may only occur as the last element in the DP in Persian sentences.

4.1.5 Persian Verb Phrases: *light verb* constructions and the compositional proposal of Hale & Keyser (1993; 2002)

As already discussed here (in section 4.1.1 and 4.1.2), the verb in Persian usually occurs in the sentence-final position, with objects, adverbials and adjuncts preceding it. The relative order of the direct object and the indirect object or PP may be modified based on the specificity of the direct object.

(33-4) Shirin be khar-hâ nân dâd (Franco, 2004)
Shirin to donkey-Plur bread gave/3sg
"Shirin gave (some) bread to the donkeys."

(34-4) Shirin nân râ be khar-hâ dâd
Shirin bread Obj to donkey-Plur gave/3sg
"Shirin gave the bread to the donkeys."

The verb agrees in number and person with the subject of the clause. However, if the subject is inanimate, the agreement may default to the third person singular.

An interesting fact about Persian syntax is that simple verbs are quite rare compared to the number of light verb constructions, also known as *complex predicates*, in the language (Harley, Folli and Karimi, 2003[77]). These constructions consist of a noun, adjective or preposition followed by a light

[77] … And independently argued by Franco, in a manuscript for Prof. Belletti course of Morpho-syntax at the University of Siena (2004).

verb such as the verbs "do", "give" or "hit", forming non-compositional units of meaning[78].

[78] It's interesting to notice that these verbal constructions can be separated from each other by many other intervening elements (Mahootian, 1997). The object of the light verb, for instance, may appear between the two parts of the construction as shown in (i) for the light verb construction *âsheq shodan* (fall in love). In (ii), the light verb predicate *afzâyesh yâftan* (increase) has been separated by the adjective *shadid*, which is behaving as an adverb. The example (iii) represents the light verb construction *xâstâr shodan* (request) with an intervening object, which itself consists of a complex noun phrase composed of a DP and a PP. Examples are from Mahootian, 1997)

(i) majnun âsheq-e leyli shod
Majnun lover-Ez Leyli became
`Majnun fell in love with Leyli.'
(ii) shomâr-e bikâr- ân afzâyesh-e shadid-i yâfte ast
number-Ez unemployed-Plur increase-Ez intense-Indef found is
`The number of the unemployed has severely increased.'
(iii) englis xâstâr-e moshârekat-e rusiye dar hall-e bohrân-e kozovo shod
England requester-Ez cooperation-Ez Russia in solving crisis-Ez Kosovo became
`England requested Russia's cooperation in solving the Kosovo crisis.'

In all of these examples, the separated parts of the light verb are still to be recognized as one unit. However, in certain cases, the separated constituents lose the light verb construction meaning. Compare the two sentences in (iv). In (iv.a), the light verb construction is interpreted as a unit, whereas in (iv.b), the intervening object marker splits the light verb construction. In this case, the nominal part *jâru* (broom) has become the direct object of the verb *zadan* (to hit). A similar effect is obtained by the relativization of the nominal part in (v). Examples from Mahootian (1997)

(iv) a. vaqti vâred shodam nader dâsht jâru mi-zad
when enter became-1sg Nader had-3sg broom Imp-hit
`When I entered, Nader was (in the process of) sweeping.'
b. vaqti vâred shodam nader dâsht jâru râ mi-zad
when enter became-1sg Nader had-3sg broom Obj Imp-hit
`When I entered, Nader was (in the process of) hitting the broom.'

(v) a. nader dishab zamin khord
Nader last night floor eat-Past-3sg
`Nader fell last night.'
b. zamin-i râ ke nader khord bâvar nakardani bud
floor-Encl Obj that Nader ate-3sg unbelievable was
`The floor that Nader ate was unbelievable.' [Not `Nader's fall was unbelievable.']

However, there are constructions like the one in (vi), with the light verb predicate latme zadan (damage), in which, even when the nominal element is relativized (cf. par.3.1.2), the light verb construction still obtains.

(vi) a. tagarg dishab be baq-e man latme zad (Megerdoomian, 2001)
hail last night to garden-Ez my damage hit-Past-3sg
`The hail damaged my garden last night.'
b. latme-i râ ke tagarg be baq-e man zad bâvar nakardani bud
damage-Encl Obj that hail to garden-Ez my hit-3sg unbelievable was
`The damage that the hail caused to my garden was unbelievable.'

The examples discussed in this note show that light verb constructions do not form a really unified category. I believe that some researches are required, however, to be able to classify in a better way the various Persian light verb predicates based on their properties.

Complex verbs have gradually replaced simple verbs in Persian since the thirteenth century (Harley, Folli, Karimi, 2003). The tendency to form complex verbs has resulted in the existence of two sets of verbs, simple and complex, for a number of verbal concepts[79]. In many cases, the application of the simple verb is restricted to the written and elevated language. A few examples of simple/complex pairs is given in (35-4) (See Karimi, 1997 for more detailed examples). The productivity of Complex Predicates formation is such that it has completely replaced the former morphological rule of simple verb formation in the Persian language.

(35-4) *Simple* *Complex*

lasidan	las zadan (flirtation doing) *'to flirt'*
raghsidan	raghs kardan (dance doing) *'to dance'*
agahanidan	agah kardan (informed making) *'to inform'*
aghazidan	aghaz kardan (start doing) *'to start'*

The light verb *kardan* "to do/make" has almost entirely lost its heavy interpretation, and is the most productive light verb (Franco, 2004). The Light verb *shodan* "to become" is systematically used in passive or unaccusative constructions. Furthermore, it's crucial to notice that a Persian Complex Predicate cannot be considered a lexical unit since its non verbal element and the light verb may be separated by a number of elements, such as negative

[79] A note on Non-Finite Categories: the verbal infinitive is rarely used in Persian, except in certain specific cases with verbs that have ingressive aspect (according to Levin (1993), verbs of beginning.) In this case, the infinitive is preceded by *be*, 'to'.

(i) Dast-im suru-mi-kaerd-im be sam xordaen
had-1P start-DUR-did-1P to dinner to eat
'We were starting to eat dinner.' (Mahootian: p.242)

The same meaning can be expressed, however, using the subjunctive, inflected for person and number.

(ii) Dast-im suru-mi-kaerd-im sam bo-xor-im
had-1P start-DUR-did-1P dinner SBJN-eat-1P
'We were starting to eat dinner.' (Mahootian: p.242)

The past participle is used to form the passive (along with the auxiliary 'become') and the pluperfect (with the auxiliary 'be'.) The present participle shows no agreement and is typically interpreted with an adverbial meaning.

(iii) bache-ha gerye-konan doid-aend kune
child-PL cry-do.PRPT ran-3P home
'The children ran home crying.' (Mahootian: p. 253,)

and inflectional affixes, the auxiliary verb for future tense and emphatic elements, according to Mohammad and Karimi (1992). Then, the meaning of these light verb constructions cannot be obtained by translating each element separately as the examples illustrate:

(36-4) zamin xordan	"floor eat"	to fall
zendegi kardan	"life do"	to live
gul zadan	"deception hit"	to deceive
shekast dâdan	"defeat give"	to defeat
az dast dâdan	"from hand give"	to lose

Persian complex verbs constructions can also be used as purely idiomatic expressions: see the following example:

(37-4) del be daryâ zadan "heart to sea hit" to take a risk

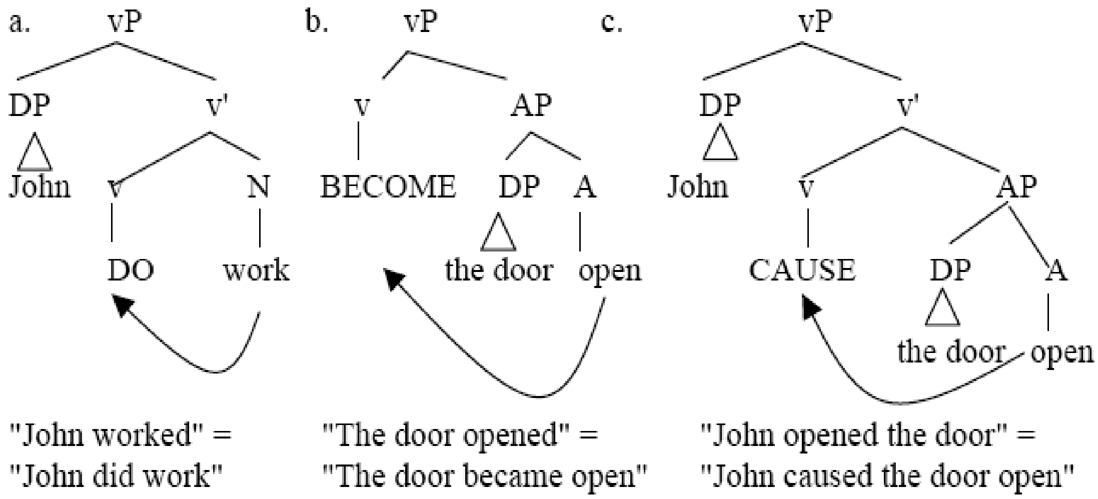
In any case, these complex predicates are extremely productive in Persian. New verbs are formed following this pattern, by joining a nominal or adjectival word to a light verb as shown in Franco (2004):

(38-4) e-mail zadan	"e-mail hit"	to (send) an e-mail
klik kardan	"click do"	to click (on a mouse)

Probably the most interesting aspects of Persian Complex verb is that they seem to represent a strong empirical argument for the VP compositional analysis developed by Ken Hale and Samuel Jay Keyser (1993; 2002).

Hale and Keyser discuss how predicate argument structure, theta-roles, and verbal alternations can be accounted for with a syntactic theory of the lexicon. They assume that most verbs have an underlying VP-shell structure (similar to Larson 1988 and Harley 2000). They also claim that x-bar theory and binary branching follow from *Unambiguous Projection*. Hale and Keyser wish to explain why the set of -roles is limited, and why the UTAH might hold (identical theta-role relationships correspond to identical structural relationships). They claim that we can explain both facts by assuming that "theta-roles" are really just names for structural configurations. See below a graphic example of their proposal taken from Hale and Keyser (1993):

(39-4)



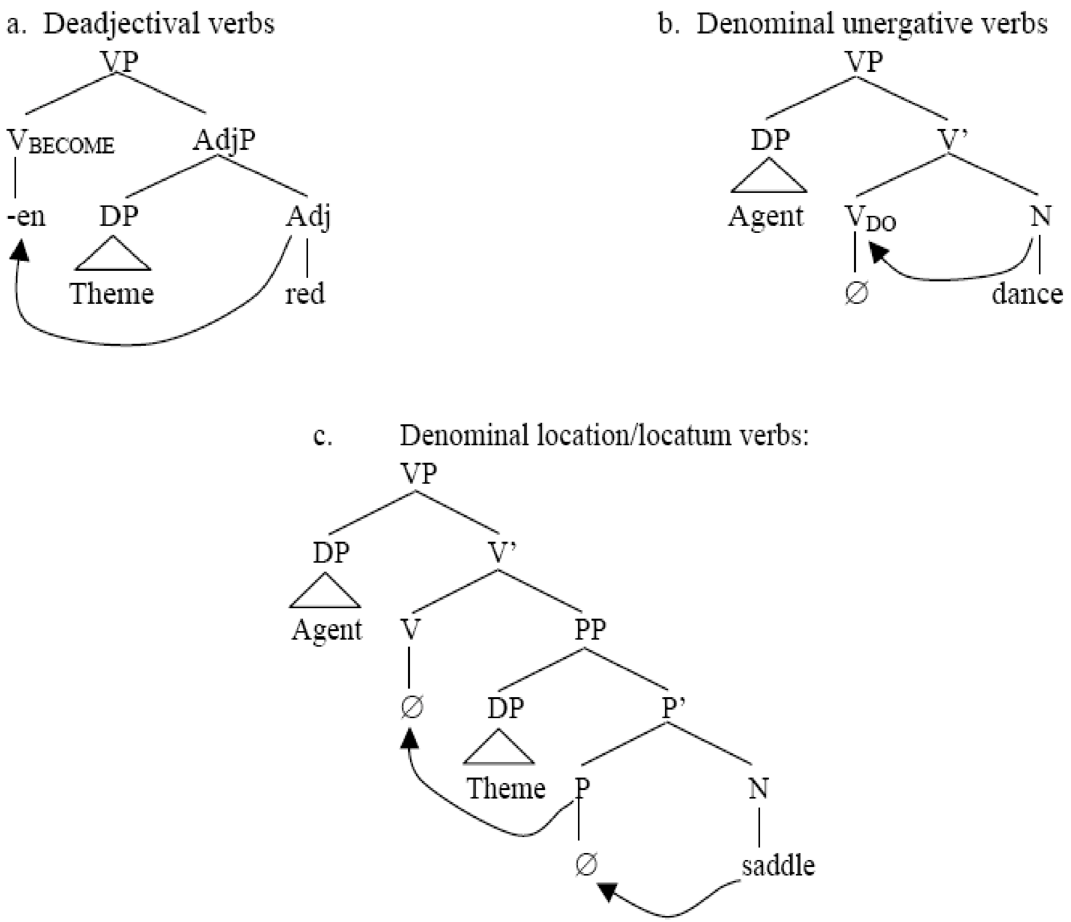
They assume a limited set of phrasal categories (V, N, A, and P) to account for the limited number of theta-roles and claim that the semantic content of each theta-role (e.g., *agentivity*) follows from the constructions they represent. They propose, in example, the following (partial, for convenience) list of definitions for theta-roles:

i) Agent: Specifier of a VP with a VP complement.
ii) Theme: Specifier of a VP with a PP or AP complement.

Then, in order to explain why denominals verbs can't form transitives, Hale and Keyser assume that denominal VPs have no spec-VP. They justify this on the grounds that NPs don't semantically license an argument, and so the principle of Full Interpretation (cf. Haegeman, 1996) won't permit one. Then, they go further to say that the subject is generated "externally" at the level of IP and use their framework to explain several alternation patterns (*middle*, *inchoatives*, etc.) for certain classes of verbs. Substantially, they base their explanations on the idea that verbs can require an outer spec-VP, if their meaning relates to the agent. For example, they say that the verb "smear" indicates the manner of action of the agent, and thus, the verb can't be used without an agent. As a result, we can't get the inchoative: *"Mud smeared on the wall"*.

In other words, verbs, in their view, are not syntactically simplex items, but rather are composites of a light verb and a non-verbal syntactic element. The surface form of the verb results from incorporation of one or more heads in the nonverbal constituent with the light verb. Their analysis deals with three main kinds of non-verbal constituent: *bare noun heads, adjectival small clauses,* and *prepositional small clauses*. Hale and Keyser analysis draws its primary inspiration from English (but includes an incredible set of data from native American languages), where the categorial status of adjectival and nominal verb roots is very clear. I give a representation of Hele and Keyser's underlying structures for denominal (*unergative* and *location/locatum*) and deadjectival verbs:

(40-4)



This approach makes the difference between unergative and unaccusative verbs depend on more than the X-bar notation. It explains the "semantic-morphological" properties of verbs of these classes. In many languages, the verbalizing part of the structure is visibly morphologically realized as an affix or light verb, as in these examples from Hale and Keyser (2002).

(41-4)

a. negar egin "to cry" (Basque)

cry *do*
jolas egin "to play" …*and many more*
play do
b. di-yin "to breath" (Navajo)
do breath
di-zheeh "to spit" … *and many more*
do spit

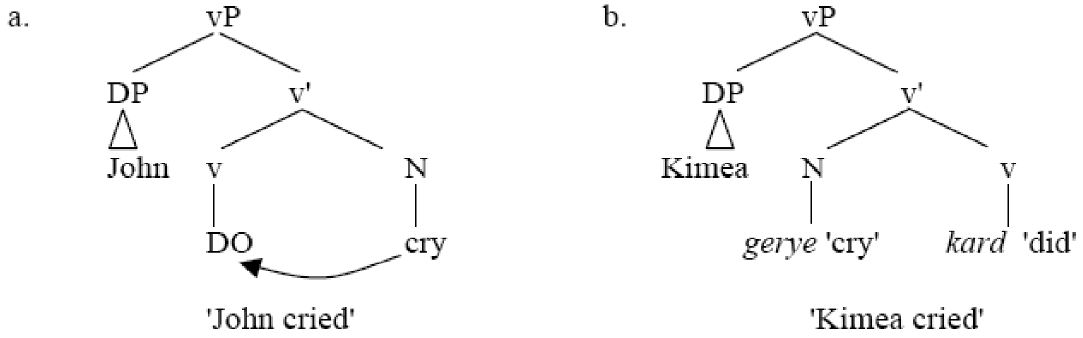
On such an approach, the thematic properties of a particular verb are dependent on the syntactic and semantic properties of the verbalizing functional element and of the non-verbal constituent which make it up. Changing the properties of the verbalizing element — the *light verb* — results in a change in Agent selection: the light verb is responsible for the presence or absence of an external argument. Similarly, the causative/ inchoative alternation in pairs like *John opened the door/The door opened* is also the result of varying the light verb, although the morphological consequences of this variation are invisible in languages such as English or Italian. Each of Hale and Keyser proposed underlying structures for English verbs, above, have natural non-incorporated counterparts in Persian complex predicate constructions, where the light verb and non-verbal element are realized separately. Furthermore, the agentivity of a particular complex predicate is dependent on the light verb involved, and the *telicity* of the complex predicate is dependent on the non-verbal element involved, in a very transparent way (Harley, Folli, Karimi, 2005).

Persian is a language in which the complex syntactic nature of verbs is very easily discerned, and in which Hale and Keyser's proposals concerning the structure of the verb phrase find wide confirmation.

4.1.5.1 Deriving Persian argument structures (Harley, Folli, Karimi 2003)

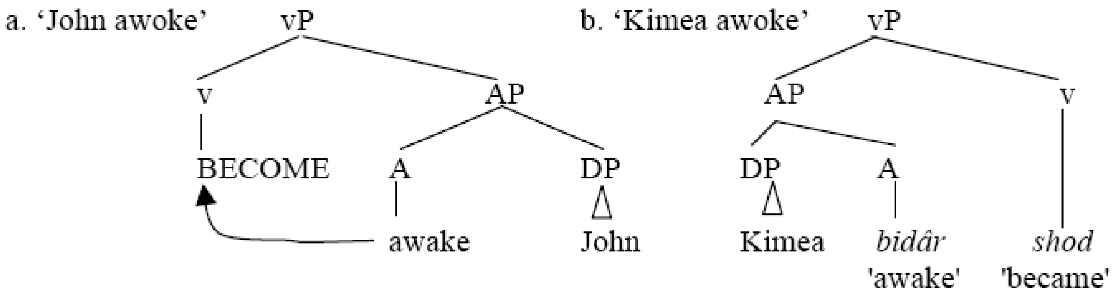
We argued that unergatives are formed when a nominal element is incorporated into a light verb which selects for an external argument. Similarly, inchoativesresult when an adjectival element is incorporated into a light verb which does not select for an external argument. These structures translate naturally to Persian complex predicates (Haely, Folli, Karimi, 2003). Consider the representation of a complex predicates like *gerye kardan*, "weeping doing" that translates as a typical unergative like *cry*:

(42-4)



Similarly, consider the syntax of a Complex predicate that translates as a typical inchoative, like *bidâr shodan* “awake becoming”:

(43-4)



Just as hypothesized by Hale and Keyser for the English causative/inchoative alternation, the alternation between the inchoative and the causative of *awake* in Persian is accomplished by changing the light verb from the equivalent of 'become' (*shodan*) to the causative 'make' (*kardan*).

Probably, the Persian case constitutes the strongest possible evidence for the syntactic nature of *l-syntax* as proposed by Hale and Kaiser.

4.2 The Ezafe puzzle

Now, I give a detailed review of previous analyses of the ezafe phenomenon in the generative framework (cfr. Samiiam, 1983; 1994; Ghomeshi, 1997; Kahnemuyipour, 2000; Franco, 2004; Larson and Yamakido, 2005; Samvelian; 2006 among others) and I develop a graph analysis of the Ezafe based on Den Dikken and Singhapreecha (2004), where the authors give a cross-linguistic account (the point of departure was the comparison between Franch and Thai) of the noun phrases in which linkers occur, in terms of DP-internal Predicate Inversion (see also Moro, 1997 and Den Dikkken 2006).

4.2.1 An introduction to Ezafe

A number of West Iranian languages - Persian, different Kurdish dialects, Hawrami, Zazaki (Larson & Yamakido, 2005) - share several aspects in their noun phrase structure:

i) The surface word order pattern is strongly head-initial. Adjectival modifiers, the possessor NP, prepositional phrases and the relative clause follow the head noun, which may only be preceded by some determiners (in example demonstratives, cardinals and quantifiers), and in very few cases by an adjective (cf. paragraph 4.1.3).

ii) Possession is expressed by means of a bare NP (DP) which follows adjectival and some prepositional modifiers[80].

iii) Elements occurring between the head noun and the possessor NP are linked to the head and to one another by the Ezafe, realized as an enclitic morpheme.

iv) Prepositional complements appear outside the Ezafe domain and follow the possessor NP (DP)[81]

The following Persian NP exemplifies these points:

(44-4) in lebâs-e sefid-e bi âstin-e Maryam
this dress-EZ white-EZ without sleeve-EZ Maryam
"this Maryam's sleeveless white dress"
(Samvelian, 2006)

[80] The expression of possession by means of an NP in close construction with the head noun, and, to some extent, the Ezafe construction is reminiscent of the Semitic construct state construction (Borer, 1988). Despite the fact that the possessor NP is not constrained to be strictly adjacent to the head noun, as it is the case in construct state nominals, the constituents occurring between the head noun and the possessor NP have been nevertheless assumed to be subject to some significant constraints, leading to the analysis of the Ezafe domain as a domain of bare heads (X°s) adjunction in Persian (Ghomeshi, 1997). This is reminiscent of the word-like properties of construct state nominals (Borer, 1988).

[81] It's interesting to notice that the word order pattern is identical to that of the Celtic noun phrase. However, unlike Celtic languages, the word order in the noun phrase does not parallel the one in the clause structure. Although Persian is verb final, the reversed order within the noun phrase has provided motivation for the application of the head movement analysis to the nominal domain in some works (Kahnemuipour 2000; Franco, 2005).

The Ezafe construction has been a particular focus of interest in different recent studies (Samiian, 1983; 1994; Ghomeshi 1997; Kahnemuyipour, 2000; Larson and Yamakido, 2005 among others). Actually this construction raises several issues in syntax (and also morphology, see Samvelian, 2006) mainly the status of the Ezafe itself.

The Ezafe has generally been assumed by Persian grammars (see Lazard 1992) to be semantically *vacuous*. Furthermore, it can be iterated within the NP, occurring as many times as there are modifiers. But, at least in Persian, it is not the expression of a concord between the head noun and its dependants (this is not a case of some Kurdish dialects; see below).

On the basis of these observations, Samiian (1983) and Ghomeshi (1997) propose not to view the Ezafe as a morpheme at all, but rather as an element inserted in Phonological Form (see Chomsky, 1981). For Ghomeshi (1997) - maybe the leading analysis of this phenomenon - the need for the Ezafe vowel results from the fact that nouns being non-projecting in Persian, a "phonological linker", in example the Ezafe, must be present in order to indicate phrasing within the nominal constituent.

This view of the Ezafe has been rejected in subsequent studies and various alternative analyses have been suggested. Ezafe has been seen:

i) as a Case-marker (Samiian 1994, Larson and Yamakido 2005; 2006).

ii) as a marker associated with the syntactic movement of the noun and realizing a "strong feature" (Kahnemuyipour, 2000).

iii) as a the morphological *ouvert* item of a functional head in the domain of AP, in a "cartographic approach" (Franco, 2005, following Cinque, 1994).

iv) as a suffix attaching to the head and to some of its intermediate projections, and marking them as awaiting a modifier or a complement. (Samvelian, 2006, following Nichols, 1986).

In the following sections work, after an historical *excursus* and the review of the most interesting analysis of the Ezafe phenomenon in the generative paradigm, I will made a new *graph based* proposal following some observations developed by Den Dikken and Singhapreecha and Den Dikken (2006) for Chinese – Mandarin, which may lead us to consider Ezafe as a linker indicating subject predicate inversion.

This view of the Ezafe is quite the opposite of the Case-marker analysis suggested by Samiian (1994) and Larson and Yamakido (2005; 2006), according to which the Ezafe is rather a dependent marking device.

4.2.2 The Ezafe construction: a rough historical perspective and a basic overview of Ezafe domain

The Ezafe construction is a specificity of those languages that display a head-initial word-order pattern within their DP (e.g. Persian, Kurdish dialects, Hawrami, Zazaki, Kermanian dialects, etc). The correlation between the head-initial word order pattern and the availability of the Ezafe may be accounted for on historical grounds[82] (cf. Samvelian, 2006). The enclitic Ezafe has probably its origin in a demonstrative-relative morpheme in Old Iranian. In Persian, it can be related to *hya* (*tya*), a demonstrative, linking the head noun to adjectival modifiers, to the possessor NP and also to a relative clause in Old Persian:

(45-4) Kāra **hya** manā [Darmesteter (1883) *from* Samvelian (2006)]

'my army; the army which is mine'

(46-4) kāsaka **hya** kapautaka [Meillet (1931) *from* Samvelian (2006)]

'the blue stone'

(47-4) vivānam jatā utā avam kāram **hya** dārayavahauš xšāyahiyhyā. [Meillet (1931) *from* Samvelian (2006)]

'Beat Vivâna and this army which declares itself as a proponent of the king Darius.'

It's interesting to notice that *hya* (*tya*) is not a simple *linker*, but that it further has a demonstrative value. The demonstrative *hya* (*tya*) can function as a head by itself:

(48-4) ima tya adam akunavam [Meillet (1931) *from* Samvelian (2006)]

'This is what I did'

[82] However, there is no necessary correlation between the head initial word order pattern within the NP and the Ezafe. Some South-western Iranian languages, which are very close to Persian, dispense with the Ezafe. In different Kermanian dialects, for instance, the Ezafe, although available, due to a close and longstanding contact with Persian, is hardly ever used or is optional (Rebuschi, 2002). Similar facts are also observed in some North Western Iranian languages, such as Tâti dialects (Lecoq 1989) or in Southern Kurdish dialects (Fattah 2000).

Hya (*tya-*) becomes *–i* in Middle Persian and progressively looses its demonstrative value to end up as a simple linker. Contrary to Persian, Kurdish and Zazaki (cf. Larson & Yamakido, 2006) have still a so-called "Demonstrative Ezafe", different from the affixal Ezafe, which functions as a demonstrative pronoun heading nominal phrases, as shown in the following examples.

(49-4) yê dwê … yê sêyê
EZ second EZ third
"the second one, the third one"
(Kurmanji Kurdish, from Larson & Yamakido, 2006)

(50-4) kitêb-î min o hî to
book-EZ my and EZ-your
'my book and yours
(Sorani Kurdish from Samvelian, 2006)

Nowadays, when available, in Western Iranian languages the Ezafe generally links the head noun to its adjectival modifiers and to the possessor NP, as illustrated by the following examples for Persian taken from Kahnemuyipour (2000) and for Sorani Kurdish taken from Samvelian (2006):

(51-4) lebâs-e sefid-e donya (Persian)
dress- EZ white- EZ Donya
"Donya white dress"

(52-4) kirasêk-î hin-î Narmîn (Sorani Kurdish)
dress-EZ blue-EZ Narmîn
"a blue dress of Narmin's"

Furthermore, the complement of an adjective can also be introduced by the Ezafe:

(53-4) Saloomeh mašqul-e kâr ast (Persian)
Salomé occupied-EZ work be-3sg-pres
'Salomé is busy working'

The fact that adjectives can take the Ezafe is not surprising. Indeed, adjectives behave like nouns in many respects, so that in Persian, for instance, it is quite impossible to establish a *distinct class* of adjectives, and several items are indistinctly used as nouns or adjectives, depending upon the context (Lazard, 1992).

A more interesting empirical observation is the use of the Ezafe with some prepositional heads. This occurs in Persian, for instance, as illustrated by the following examples:

(54-4) a. barâ-ye Saloomeh
for-EZ Salomé
b. aleyh-e Saloomeh
against-EZ Salomè
"for Salomé" ; "against Salomé"

It has been argued by Ghomeshi (1997) that prepositions occurring with the Ezafe are not in fact prepositions, but *nouns*.

Real prepositions such as *bâ* "with", *az* "from"etc., by contrast, never occur with the Ezafe (cf. also Chapter 5). This assumption is arguably appropriate for locative prepositions, such as *zir* "under", *pošt* "behind", which are originally nouns and display a range of nominal properties (Samiian, 1994; Larson and Yamakido, 2005): *the phrase they head can function as the subject or the direct object of a sentence.*

It faces however serious problems when applied to items such as *barâ* "for", *alâraqm* "despite", and *aleyh* "against", which have none of the distributional and morphological properties of nouns[83]. Consequently, the analysis of these items as nouns is exclusively motivated by the fact that they can be marked by the Ezafe. Anyway, not only is it unclear what such an analysis could gain from it, but also far more mysterious is the way it could work!

Contrary to Ghomeshi (1997), and according to Larson and Yamakido (2005), I think that is possible to consider these items as prepositions, which implies that, with regard to the Ezafe, prepositions have, simply, two distinct subtypes: *those which take the Ezafe and those which do not take the Ezafe* (this fact will have some consequences for some further discussions raised in the following Chapter).

[83] For instance, the constituents they head can never be the subject or the direct object of a sentence (cf. Samvelian, 2006).

Apart from its typical uses to introduce adjectives and the possessor NP, the Ezafe morpheme can introduce prepositional phrases and adverbial phrases. The possibility for prepositional phrases to be introduced by the Ezafe in Persian is illustrated by the following example takan from the novel *Yek ruz mânde be eyd-e pâk* by Z. Pirzâd and cited in Samvelian (2006)

(55-4) ne-mitavânest-am tasmim begiram sobh-hâ-ye [$_{PP}$ bâ mâdar-râ] bištar dust dâr-am yâ sobh-hâ-ye [$_{PP}$ bâ kabutar-hâ-râ].
NEG-can.Past-1sg decision take-1Sg morning-pl-EZ with mother-Acc more like.Pres-1sg or morning-Pl-EZ with pigeon-pl-Acc
"I could not decide whether I loved better the mornings with mother or theones with the pigeons"

Once again, contrary to what has been claimed in some previous studies (Ghomeshi 1997, Larson and Yamakido 2005), there is no ban on the presence of PPs within the Ezafe domain, whatever be the type of the head preposition.

The situation is more contrasted with respect to relative clauses (cf. paragraph 4.1). In Persian, only reduced relatives can be linked to the head noun by the Ezafe (cfr. Samvelian 2006, from which are taken the following examples. I recommend to refer to her work for a cross-linguistic survey and for more details[84]):

(56-4) in javân-e [az Suis bar gašte]
this young-EZ from Switzerland return
"this boy returned from Switzerland"

[84] Samvelian also observes that Kurdish, by contrast, allows for all relative clauses to be introduced by the Ezafe:

(i) mirov-ê ku min dît-î (Kurmanji)
man-EZ.M.SG that I see.PAST
'the man whom I saw'

(ii) aw şâr-a-y (ka) dît-mân (Sorani)
that town-DEF-EZ (that) see.PAS-1.P
'The town that we visited'

Furthermore in the Kurmanji dialect, even a non-relative subordinate clause which is a dependent of a noun can be introduced by the Ezafe, as illustrated by the following example:

(iii) bi xayâl-â [ko aw ji bâjêr darkati bûn]
at imagination-EZ that they from city out were
'Imagining that they were outside the city...'
[taken from Bedir Khan and Lescot, 1970]

(57-4) * ketâb-i-e ke ru-ye miz ast
book-rel-EZ that on-EZ table be.PRES
"The book that is on the table"

In the following section I will try to outline, from a *diachronical* perspective, the analyses of the Ezafe-morpheme in the generative literature of the last two decades.

4.2.3 Restriction on Ezafe (Samiian, 1983)

Vida Samiian (1983) is the first detailed study on Ezafe in Persian within a modern syntactic framework, namely X-bar theory. The empirical facts mentioned by Samiian have been taken up in subsequent works (Ghomeshi 1997, Kahnemuipour 2000, Larson and Yamakido, 2005), although they have been accounted for in a radically different way. In this section, I will consider different restrictions on the Ezafe construction pointed out by Samiian (1983), then, in the following one I will then give a detailed account of Ghomeshi (1997).

Samiian (1983) points out two major types of restrictions on the Ezafe construction: the constituents occurring within the Ezafe domain are strictly ordered and constrained with regard to their distribution. In depth, according to Samiian, different elements linked by the Ezafe to the head noun occur in a fixed order:

(58-4) ketâb-e târiz-e sabz-e bijarzes-e Saloomeh
book-EZ history-EZ green-EZ without value-EZ Salome
"Salome's green history book without any value"

In the example (58-4) the head noun is followed by an attributive noun, an adjective modifier, a prepositional modifier and a possessor NP:

(59-4) Head Noun – Attributive noun – Adjective modifier – Prepositional Modifier – Possessor NP

Although Samiian (1983) considers this order to be a strict one, it must be noted that the only real constraint concerns the placement of the possessor NP, which must occur in the final position within the Ezafe domain, any other position being excluded for the possessor (cf. also Kahnemuipour, 2000).

Within this domain, other elements linked by Ezafe are by preference ordered as in (59-4) above, but they may also be ordered differently. The following example where the prepositional modifier precedes the adjective modifier is well-formed[85]:

(60-4) ketâb-e târik-e bijarzes-e sabz-e Salome
book-EZ history-EZ without value-EZ green-EZ Salome
"Salome green history book without any value"

Samiian noticed also some restrictions on the expansion of phrasal complements and modifiers within the Ezafe domain:

"The attributive noun phrase and the adjective phrase have to be head-final and the prepositional phrase of time and location cannot carry a sentential complement". (Samiian 1983: 40)

According to Samiian, the only element that can be freely and recursively expanded is the Possessor NP. On the basis of the contrast between the following examples given in (61-4a, b), Samiian concludes that attributive noun phrases surface only as bare nouns:

(61-4) a. kif-e charm
bag-EZ leather.
b. * kif-e in charm (Samiian, 1983: 46)
bag-EZ Dem leather
'leather bag' (*tentatively*) 'a bag of this leather'

Samiian (1983) also argues that adjectival modifiers as well cannot take nominal, prepositional or sentential complements when occurring within the Ezafe construction. These restrictions are exemplified by (62-4b), (63-4b) and (64-4 b) respectively:

(62-4)
a. mard-e negarân-i vâred shod (Samiian, 1983: 42)
man-EZ worried-Indef enter become.Pas

[85] All my informants from Tehran and the Mazandaran region (without any exception) say that this sentence is well-formed in Persian, both standardly written and spoken.

"A worried man entered"

b. * mard-e negarân-e bache-hâ-yash-i vâred shod
man-EZ worried-EZ child-Pl-pronIndef entered become.Pas
"A man worried about his children"

(63-4)

a. mardom-e xashmgin-e tehrân bepâ xâstand (Samiian, 1983: 42)
people-EZ angry-EZ Tehran stand.Pas
"The angry people of Tehran rose up"

b. * mardom-e xash-mgin az ertejâ-ye tehrân bepâ xâstand
people-EZ angry at reactionaires-EZ Tehran stand-Pas
"The people of Tehran angry at the reactionary forces rose up'"

(64-4)

a. mardom-e xoshhâl-e irân jashn gereft-and "Samiian, 1983: 42"
people-EZ happy-EZ Iran feast take.Pas-3.Pl
"The happy people of Iran celebrated'"

b. *mardom-e xoshhâl ke shâh kesh var râ tark kard-e irân jashn gereft-and
people-EZ happy that Shah country left do-PAS-EZ Iran feast take.Pas3.Pl

The same adjectives however may take a nominal, prepositional or sentential complement when they occur outside the Ezafe domain, in apposition for instance, as illustrated by (65-4).

(65-4) a. mard-i, negarân-e bache-hâ-yash, vâred shod
man-Indef worried-EZ child-PL-Pron.3.Sg entered become.PAS
"A man, worried about his children, entered"

b. mardom-e Tehran, xashmgin az erteja, bepâ-xâstand
people-EZ Tehran, angry at reactionaries, stand-Pas
"The people of Tehran, angry at the reactionary forces, rose up".

c. mardom-e iran, xoshhâl ke shâh keshvar râ tark-kard, jashn gereft-and
people-EZ Iran, happy that Shah country left.Pst feast take.PAS-3.PL
"The people of Iran, happy that Shah left the country, celebrated"
(Samiian, 1983: 42)

As for prepositions, relying on the following data, Samiian claims that they may appear with a nominal complement within the Ezafe domain, but that sentential complements are excluded:

(66-4)
a. âftâb-e ba'd az bârun rhashang-e (Samiian, 1983)
sun-EZ after from rain beautiful-Cop.3.SG
"The sun after the rain is beautiful"
b. * âftâb-e ba'd az in ke bârun biâd rhashang-e
sun-EZ after from this that rain come.Pres beautiful-Cop.3.Sg
"the sun after the rain come is beautiful".

c. âftâb, ba'd az in ke bârun biâd, rhashang-e
sun, after from this that rain come.Pres, beautiful-COP.3.SG
"The sun, after it has rained, is beautiful"

Despite all these restrictions, Samiian considers nevertheless that different constituents occurring within the Ezafe domain are maximal projections and proposes the following structure for Persian NPs:

(67-4) N' [N NP AP PP NP]

An insertion rule inserts, then, the Ezafe vowel and a filter eliminates all ill-formed structures.

4.2.4 Ghomeshi (1997): the Ezafe domain as a X°-adjoined structure

Ghomeshi (1997) takes an important theoretical departure in her account of the Ezafe construction and the internal structure of Persian NPs. Two major assumptions on possible syntactic configurations underlie her analysis:

i) Heads may adjoin to one another without projecting. Some X° categories are inherently non-projecting in syntax.

ii) The fact that a constituent is phrasal or not depends not only on whether the head projects, but on whether that head itself is selected by a projecting element. In other words, while certain X° categories may be inherently non projecting in syntax, they may still appear as XPs, provided they are selected by a projecting head.

On the basis of these assumptions, Ghomeshi puts forward *three* significant hypotheses:

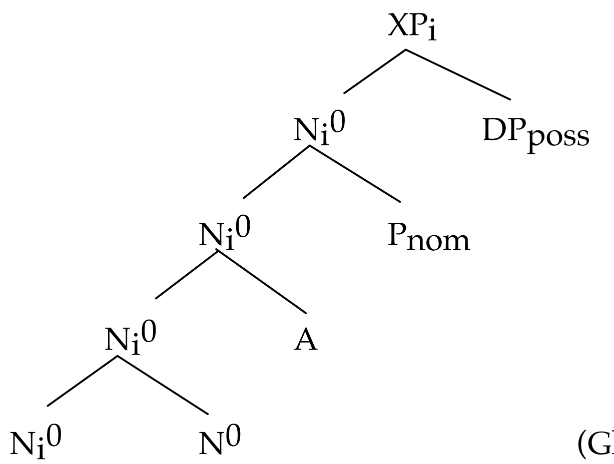
i) Persian nouns are inherently non-projecting. This means that they never appear with filled specifier and complement positions and that an NP node cannot dominate any phrasal material.

ii) In spite of the fact that they are non-projecting, Persian nouns may still appear as NPs, provided they are selected by a projecting head, a Determiner (D°);

iii) Ezafe vowel never attaches to a phrasal constituent. This implies that the Ezafe domain is the domain of X°s, within a constituent with [+N, -V] features (i.e. nouns and adjectives). The elements occurring within the Ezafe domain are just bare heads, be they nouns, adjectives or prepositions.

The internal structure for Persian NPs which emerges from these assumptions is the one given in (68-4) below:

(68-4)



(Ghomeshi 1997: 95)

The Ezafe Insertion rule, stated in (69-4) and operating in PF, inserts the Ezafe vowel when necessary:

(69-4) Ezafe Insertion Rule [Ghomeshi, 1997: 91]

Insert the vowel *–e* on a lexical X° head that bears the feature [+N] when it is followed by phonetically realized, non-affixal material within the same extended projection.

One important point in (69-4) is that the possessor NP (or DP) is not dominated by NP and is instead base generated as sister to D'. This follows from Ghomeshi's assumption about the non-projecting nature of Persian nouns. Remember that, in contrast to attributive nouns and adjectival or prepositional modifiers, the possessive noun phrase is the only constituent that may be fully phrasal. But, since Persian nouns cannot dominate phrasal material, the possessor may not occur within NP. The NP internal position being thus excluded for the possessor, it may occur either as a sister to NP or as a sister to D'.

The first option is not retained by Ghomeshi, who advocates for the possessive DP to be base generated in [Spec, DP] position. Under such analysis, an empty D-head bearing the feature [+ def] is required, whose validity is further supported by the two following facts:

i) Noun phrases that include a possessor in Persian are obligatorily construed as definite or presupposed.

ii) Possessors are in complementary distribution with the enclitic *–i*, the indefinite article in Persian.

The definiteness of the noun phrases containing a possessor receives a straightforward explanation if a definite article is present, the whole noun phrase being thus a DP. The same goes for proper nouns, pronouns or nouns that occur with an overt determiner, which according to Ghomeshi are all DPs.

The complementary distribution between possessors and the indefinite morpheme *–i* is attributable to the properties of the two D-heads in Persian: the empty definite determiner assigns Case, while the indefinite *–i* does not. This prevents a possessor DP to occur with the indefinite enclitic *–i* and thus accounts for the ungrammaticality of the following example:

(70-4) * ketâb-e sorx-i maryam
book-EZ red-INDEF Maryam

In the light of this analysis, all the restrictions pointed out by Samiian (1983) are accounted for in a simple and elegant manner and no filter is necessary to eliminate ill-formed structures.

4.2.5 Ezafe as a Case marker (Samiian 1994; Larson and Yamakido 2005)

In a research that follows her 1983 study, Vida Samiian (1994) argues that Persian Ezafe *is* a case marker, inserted before complements of [+N] categories, including Names, Adjectives and (some) Prepositions:

"Ezafe is a case marker, inserted before complements of [+N] categories". Samiian (1994).

Samiian supports this claim by observing that the use of Ezafe extends considerably beyond modification. Many contexts where English would use the (*genitive*) case-marking preposition *of* are ones in which Ezafe occurs, including complements of names, complements of adjectives, and certain partitive constructions. More recently Larson and Yamakido (2005) have extended her proposal in some respects, for which we will give a detailed review.

Samiian considers Ezafe as a dummy Case assigner occurring with non-Case-assigning heads (nouns, adjectives and prepositions of the first class, see below) and enabling these heads to Case-mark their complements.

Thus, in Persian anything that does not assign Case would need Case in order to be licensed and Ezafe's function is to case-license [+N]. Given the fact that Case-marking is typically associated with argument status and not with modifiers, the question that arises then is: why modifiers would require Case in Persian?

For Samiian this is not a major problem, since she says that there are languages such as Sanskrit and Latin that Case-mark attributive adjective phrases. Thus, Samiian gives a description of the distribution and function of the Ezafe in Persian and provides a unified syntactic account in terms of a formal system of features.

As I have already pointed out, she states that Ezafe is a dummy case assigner (similar to Italian *di* or English *of*) which appears within phrases headed by non-case-assigning categories, thus enabling them to case-license their complement. This assumption provides, in any case, an interesting explanation for the presence of Ezafe before attributive nouns, but doesn't account for the Ezafe vowel before attributive adjectives (as I have argued above it is not clear why attributive adjectives need case).

Following the principles of Case Theory (cf. Haegeman, 1996) and Stowell's Case Resistance Principle (1981), Samiian assumes that non-case-assigners need case, whereas Case-assigners do not. The trigger for the insertion of Ezafe is, then, the lack of Case-assigning properties. Hence, Ezafe appears only on categories that cannot assign case, such as [+N] categories, and doesn't appear on case-assigning categories, such as [-N]. Given this, a question arises: why most prepositions in Persian take their complement via Ezafe?

Since verbs and prepositions are both case-assigners by virtue of their [-N] feature, the latter are not expected to need some special device for taking a complement. However, the fact remains that the only phrasal category where Ezafe is not found is the verb (but see paragraph 4.3 for an interesting empirical fact).

Samiian divides the prepositions in Persian in two groups — those which do not take Ezafe (Class 1; C1) and those which take Ezafe (Class 2, C2). C1 prepositions possess all the properties associated with prepositions, including the ability to directly assign case. C2 Prepositions, on the contrary, exhibit some nominal properties including the inability to assign case. In order to explain the syntactic behaviour of C2 Prepositions, Samiian adopts the *Neutralization Hypothesis* for German adjectives, for which she cites the work of van Riemsdijk (1991).

Under this proposal, German adjectives are neutralized in their [+N] feature, that is, they are specified only for the [+V] feature, rather than fully specified [+V,+N] elements. Consequently, as a [+V] category they are non-distinct from the [+V,-N] category, from verbs. This provides an explanation for the fact that adjectives and [-N] categories in German share some properties: at least, they all can assign case.

Following the same line of reasoning, Samiian suggests that C2 Prepositionss are neutralized with respect to their [-N] feature, thus they have only the feature specification [-V]. The full paradigm of Persian lexical categories according to Vida Samiian is given as follows in (71-4).

(71-4) N: [-V,+N]
V: [+V,-N]
A: [+V,+N]
C1 P: [-V,-N]

C2 P: [-V][86]

(Samiian 1994: 38)

Building on Samiian (1994) and following the Larsonian DP-shell structure[87] (cf. Larson 1991-2006), Larson and Yamakido (2005) suggest too that Ezafe is a case marker.

However, their account differs from the one suggested by Samiian. Larson and Yamakido make the interesting assumption that C2 prepositions are nouns and thus, by eliminating the distinction between most Persian prepositions and nouns, they are able to provide a unified syntactic account for all nominal modifiers. They propose that nominal modifiers are generated as arguments of D post-nominally, in the position of relative clauses. As [+N] elements they require *Case*, hence, in English, they move up to get case-licensed by the Determiner. Persian, however, has at its disposal the Ezafe marker, which according to them is a special "device" for making Case available in the base position. Thus, Ezafe allows the underlying post-nominal position of nominal modifiers to emerge, since they are case-licensed in their base position.

In other words, Larson and Yamakido propose an analysis in which (predicative) nominal modifiers originate postnominally as inner arguments of D, which only afterwards combines with NP and a subsequently merged light determiner (d) attracts the D head, deriving D–N word order.

Furthermore, DP modifiers are considered to be lowest complements of the head. Under this account, nominal modifiers, in all languages, originate as arguments of D in a post nominal position. Those DP-modifiers that do not have Case features to be checked, PPs and CPs for instance, remain *in situ*.

[86] It's interesting to notice that C2 Ps are left with only the feature [-V] which makes them unable to assign case, since according to Samiian only categories specified for [-N] are case-assigners. Therefore, C2 Ps have to make use of a special device, more specifically the dummy case assigner Ezafe, in order to be able to take complements.

[87] Here is a brief explanation of Richard Larson's DP theory. In a paper from 1991 Larson discussed the syntactic projection of DP from the standpoint of generalized quantifier theory, and argued that, under the latter, the most appropriate analogy is not between DP and CP/TP (cf. Abney, 1987; Szabolsci, 1983), but rather between DP and VP. Specifically, Larson suggests that:

> (i) DP can be understood as projecting arguments according to a thematic hierarchy that is parallel to (but different in role-content from) that found in VP,
> (ii) That Determiners sort themselves into intransitive, transitive and ditransitive forms, much like Verbs, and
> (iii) that nominal modifiers, including relative clauses, project in the DP very much like adverbial elements in VP.

On the contrary, those modifiers that bear Case features (for instance APs) are required to move to a site where they can check Case. The hypotesis of Larson and Yamakido is fascinating. The prenominal position is assumed to be such a site and there are languages such as Persian however that have in their D-system an item that can be inserted to check Case on [+N] determiner complements, allowing the latter to remain *in situ*: Ezafe would be the Case-marking device.

The analysis of Ezafe as a Case marker, anyway, faces several problems. The data on which it relies is not well grounded. The major argument invoked by both Samiian (1994) and Larson and Yamakido (2005) to support this analysis is the fact that constituents such as PPs and relative clauses, which no not require to be Case-marked, are excluded from the Ezafe domain, but other authors (cf. Samvelian, 2006 for another critical survey) have empirically demonstrated that in Persian PPs headed by P1s, when they are modifiers, as well as adverbial phrases occur within the Ezafe domain.[88]

Furthermore, since under Larson and Yamakido's account, Ezafe is supposed to enable [+N] modifiers, which otherwise should move to a prenominal position, to remain *in situ*, it is unclear why in other languages, for instance, *reduced relatives* are allowed to remain *in situ* without being Case-marked, while in West Iranian languages such a Case-marking device is necessary in order to let them remain in a post-nominal position.

The view of Ezafe as a Case-marker becomes even more problematic when other West Iranian languages are taken into account. First, as reported in Samvelian (2006), in almost all groups of Kurdish dialects *restrictive* relative clauses may be introduced by Ezafe; In addition, in Kurmanjî dialects, which have generally maintained morphological case marking, the Possessor NP linked to the head noun by Ezafe appears in oblique case, as shown by the following example, taken from Samvelian (2006):

[88] Furthermore, though relative clauses cannot be linked to the head noun by Ezafe in Persian, reduced relatives, on the contrary, can be introduced by Ezafe. This is shown by the following attested examples:
(i) ...nazm-e ostân tavassot-e in javân-e [az suis bar gashte]RRC bishtar hâsel xâhad âmad
order-EZ province by means-EZ this young-EZ from Switzerland back turn.PP more gained AUX come.PAS
'(...) the province's order will be better established by this young man came back from Switzerland'

(ii) aks-e [châp shode dar ruznâme]RRC aks-e râvi-e dâstân ast17
photo-EZ publication become.PP in newspaper photo-EZ narrator-EZ story be.PRES
'The photo published in the newspaper is the photo of the story's narrator'

It is unclear why constituents such as PPs and reduced relatives would require to be Case-marked in Persian.

(72-4) mashl-ah narmîn-ê
house-EZ.Fem Narmin-Obl.Fem
"Narmin's house"

Viewing Ezafe as a Case marker would imply that the possessor NP *Narmin* is case marked twice for the same function (cf. also Kahnemuyipour, 2000) and this is problematic within any theory of Case marking.

Given this, either the Persian Ezafe is a radically different item from its Kurdish counterpart, or Ezafe is not a Case-marker, neither in Persian nor in other Iranian languages. The fact that PPs and reduced relative clauses are linked to the head noun by Ezafe (at least in Persian) strongly supports the latter conclusion.

4.2.5 Ezafe and movement (Kahnemuyipour, 2000)

Kahnemuyipour (2000) provides an explanation for Ezafe insertion based on syntactic movement. He notes that if Ezafe were a marker inserted only to identify constituent-hood, as proposed by Ghomeshi (1996), then the order of the modifier and the noun would be irrelevant. However, there are cases in Persian where the adjective precedes the noun and no Ezafe is inserted (cf. (73-4)). Moreover, the Ezafe vowel is ungrammatical in this context.

(73-4) a. *gol-âb* flower-water "rose-water" vs. *?âb-e gol*
b. *bozorg-mard* big-man "great man" vs. *mard-e bozorg* 'big man'
c. *ketâb-xune* book-house "library" vs. *?xune-ye ketâb*

(Kahnemuyipour 2000:3)

Kahnemuyipour takes this fact to suggest that the Ezafe construction is associated with syntactic movement and that the Ezafe vowel is the realization of a strong [Mod] feature borne by modifiers. He assumes a left-branching structure and a prenominal Merge position for all noun-modifying elements.

Their postnominal surface position, then, is derived by movement of the noun. Referring to Cinque's (1990) proposal about the base position of adjectives in the noun phrase, namely in the specifier of functional phrases above the NP, and according to my proposal, independently developed in Franco (2004), Kahnemuyipour suggests that modifiers in Persian too head functional projections above the noun phrase and, furthermore, that they bear the strong feature [Mod]. The noun, which also bears the feature [Mod], moves up and head-adjoins to the modifier, thus checking its [Mod] feature against the [Mod] feature of the modifier. The [Mod] feature is then morphologically realized as Ezafe on the noun. Kahnemuyipour doesn't tackle the issue of those prepositions that take their complement via Ezafe. It remains unclear whether they are considered to originate below the *Ground* complement (cf. Franco, 2004) and then move up to head-adjoin to it, which would mean that the preposition is modified by its complement.

To resume in some points his proposal, Kahnemuyipour (2000) suggests that the Ezafe marker is associated with syntactic movement and suppose for Persian:

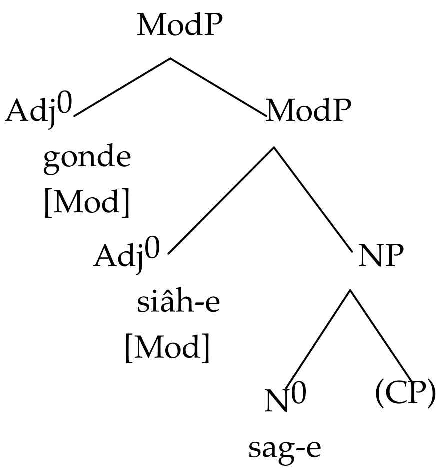
i) Right branching structure.
ii) Prenominal Merge position for adjectives, modifying nouns, possessors, etc.
iii) Basing on Cinque (1990) and Rubin (1997), he assumes that adjectives are located in the heads of functional projections ModP above NP.
iv) The adjectives (and all elements that modify nouns) bear a feature [Mod].
v) The feature [Mod] is strong and triggers overt movement of the noun.
vi) The noun moves up, head-adjoins to the adjective and checks the strong feature [Mod] against the [Mod] feature of the Adjective[89].
vii) The strong feature [Mod] is morphologically realized on the noun element by Ezafe.
viii) In this way, the postnominal surface position is derived by successive head adjunction to check the strong feature [Mod].

The representations of the derivational stages of this analysis are shown below:

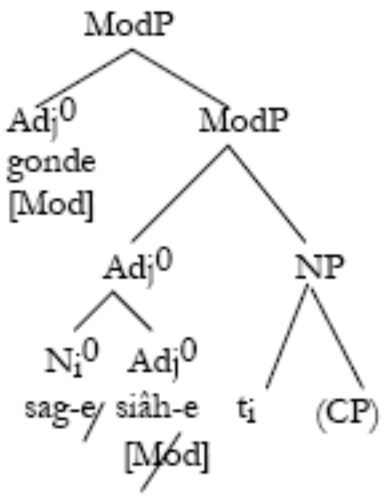
(74-4) sag-e siah-e gonde
dog-Ez black-Ez big
"big black dog"

[89] Note that the order of adjectives in Persian doesn't appear to be as strict as this proposal would predict (cf. Franco, 2004).

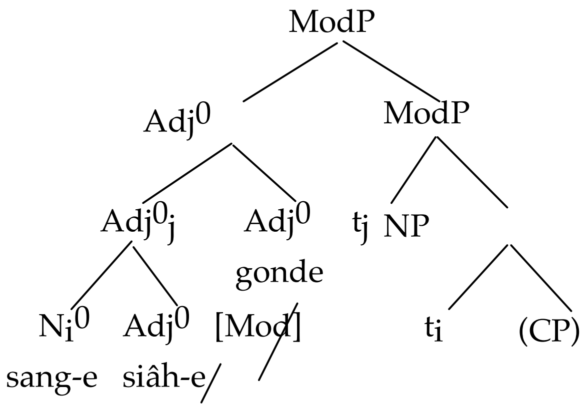
a.


ModP
Adj0
gonde
[Mod]
ModP
Adj0
siâh-e
[Mod]
NP
N0
sag-e
(CP)

b.


ModP
Adj0
gonde
[Mod]
ModP
Adj0
Ni0
sag-e
Adj0
siâh-e
[Mod]
NP
ti
(CP)

c.


ModP
Adj0
Adj0j
Ni0
sang-e
Adj0
siâh-e
Adj0
gonde
[Mod]
ModP
tj
NP
ti
(CP)

4.2.6 An inflectional affix? (Samvelian, 2006)

Another view of the Ezafe phenomenon is the one of Samvelian (2006) already cited here for many interesting cross-linguistic examples, who argue that the Ezafe in Persian could be regarded as an *inflectional* affix, attaching to a head noun and to some of its intermediate projections and marking them as awaiting a modifier or a single NP complement.

Samvelian also demonstrate that the affixal analysis of the Ezafe could be applied to Kurmanji, though the Ezafe construction does not display the same range of properties as in Persian.

The analysis outlined in Samvelian's paper entails that the Ezafe particle, whose origins in Modern Persian can be traced back to the Old Persian relative/demonstrative *hya*/*tya* (see above paragraph 4.2.1), has undergone a process of reanalysis-grammaticalization, being thus reinterpreted as a part of the nominal inflection.

Given its enclitic status (at least in Modern Persian), it could be assumed that the conflict arising from the requirement for two opposite directions of attachment – morpho-syntactic attachment to the right and phonological attachment to the left – has been resolved by the *reanalysis* of the Ezafe as a nominal inflectional affix, thus aligning morpho-syntactic attachment with phonological attachment.

Such a view assumes that Ezafe particle has ceased to function as a relative particle, specializing as a *device* for nominal attribution.

Samvelian think that, on the basis of distributional, prosodic and morphological criteria, two major sets of inflectional affixes within the Persian NP will be established. The members of the first set, i.e. the definite suffix –(*h*)*e* and the plural suffix *hâ*, may be considered as word-level inflectional affixes: they attach to the head (i.e. the noun) within the NP and cannot be separated from it by any other inflectional affix. Furthermore, they bear lexical *stress* and cannot have wide *scope* over the coordination of two nouns. The members of the second set, i.e. the Ezafe, the determiner –*i* and personal enclitics, are argued to be phrasal affixes: they occur at the right edge of nominal non-maximal projections, and are located after Set (1) inflectional affixes. See the examples below, taken from Samvelian (2006; p. 13).

(75-4)

a. in bâr âhang hamân-i bud ke pesar-e-ye film-e hendi

barâ-ye doxtar-e mi-zad
this time melody same-encl be.Pas that boy-Def-EZ film-EZ Indian for-EZ girl-Def Imp-beat.Pas

"This time the melody was the same as the one the boy in the Indian film was playing for the girl".

b. * ketâb-i-e Maryam
book-Ind-EZ Maryam
"a book of Maryam"

c. * hamsâye-ye negarân-e bachecehâ-yash-e Maryam
neighbour-EZ worried-EZ child-P-PAF.3.P-EZ Maryam
"Maryam's neighbour who is worried about his children"

In brief, Samvelian's work suggests a morphological account of these restrictions in terms of position class morphology (Stump, 2001) where collections of items compete for realization in a single position.

In this perspective, the data in 75-4) receive a purely surface-based account, in terms of constraints on affix stacking, with no need for syntactic constraints. If this account is appropriate, it is expected that such examples would become grammatical in case of a reordering of the constituents within the NP so that affix stacking is avoided. This indeed seems to be the case, given the contrast between (76-4a) and (76-4b):

(76-4) a. *qahremân-e [rânde shode az mihan-ash]-e in roman
hero-EZ drive.Pas become.Pas from homeland-pron.3.S]-this novel
"the hero of this novel, who is driven away from his homeland"

b. qahremân-e [az mihan-ash rânde shode]-ye in roman
hero-EZ from homeland-PAF.3.S drive.Pas become.Pas]-EZ this novel
"the hero of this novel, who is driven away from his homeland"

4.3 An interesting fact: the *tense* Ezafe of the Behdînî-Kurdish Geoffrey Haig (2005)

An interesting empirical fact is reported in a paper by Geoffrey Haig, who takes a look at the Ezafe particle in an another Western Iranian language, the *Behdînî dialect* of Kurdish (BK), spoken in North Iraq. In this language, one *exponent* of the Ezafe has undergone a sort of *different* development: it is arguably no longer part of an NP (or DP) at all, but is now a particle with a particular *tense/aspect* value (feature), presumably part of a Tense projection in the clause. Typical examples that Haig has taken from MacKenzie (1961), are the following:

MacKenzie (1961)

(77-4) xusk-a min ya çuy-î sîk-ê
sister-Ez.F 1S.Obl Ez.F go:Pas-Ptcpl market-Oobl
"My sister has gone to the market"

(78-4) got-ê ku šah-ê wan yê mir-î
say:Pas-to.him that king-Ez.M 3Pl.Obl Ez.M die:Pas-Ptcpl
"(He) said to him that their King had died."

The paradigm of forms available to this particle is identical to the paradigm found for the NP-based Ezafe; MacKenzie (1961) had already pointed out that the two are *etymologically* identical. Haig (2005) refers to the latter as the *Tense* Ezafe. In MacKenzie's data, the tense Ezafe was largely restricted to co-occurrence with state or locational predicates, and participial verb forms. But the more recent fieldwork of Haig shows that the Ezafe particle now regularly occurs with finite present tense verb forms. With finite present tense verb forms the Tense Ezafe contrasts with clauses lacking such particles, indicating that the particle is indeed now part of the system of tense/aspect distinctions in the language, adding a particular sense of immediacy or current relevance:

(79-4) Ez yê xwarin-ê çê.di-k-im
1Sg Ez.M meal-Obl Imp-do-Pres-1Sg
"I am making/preparing a meal (right now)" (Haig, 2005)

vs.

(80-4) Ez xwarin-ê çêdi-k-im
1Sg meal-Obl imp-do-Pres-1Sg
"I (generally) make Kurdish food" (Haig, 2005)

Then, Haig tries to reconstruct the most plausible *diachronic* scenario that led to the current situation, noting a striking (and inspiring, *for me*) parallels to the developments of *copula* elements from nominal linkers / pronouns in Hebrew and Mandarin[90] (cf. Li & Thompson 1977 and, also, Den Dikken, 2005) and suggesting that the pathway concerned, involved the reanalysis of an originally hybrid element, the Old Iranian ancestor of the Ezafe (cf. paragraph 4.2.1), which *conflated* a C and a D projection, with the latter ultimately leading to the Tense-projection position of the BK Tense-Ezafe.

The parallels I have found in Haig (I mean the ones concerning the "evolution of the copula", especially in Chinese Mandarin), reminded me the encounters with Den Dikken (1995; 2005) and Moro (1993; 1997; 2000) theories about *copula* and, in some ways, have been an unconscious trigger for the present analysis of Ezafe.

4.4. Ezafe: Linking the Complex (network of the) Noun Phrases

The Ezafe morpheme in our analysis, partly based on Den Dikken and Singhapreecha (2004) is a *linker* which, in a traditional path, is introduced in the course of a Predicate Inversion operation that inverts a noun-phrase-internal predicate with its phrasal subject.

The constituent preceding the Ezafe morpheme could be interpreted, in fact, as the subject of the *inverted predicate*, which tells us that the word-order effect of Predicate Inversion is undone later in the derivation via *raising* of the subject to the Specifier of a higher functional projection (in a vein of a Cartographic approach) whose head is empty in the base, but gets filled by a linker as it raises. This is the most plausible account in a traditional perspective.

[90] To explain how a demonstrative pronoun (*shi*) developed into a copula, Li & Thompson (1977: 420) suggest that this change came from a topic mechanism: "the subject pronoun which is co-referential with the topic in the comment of a topic-comment construction is reanalyzed as a copula morpheme in a subject predicate construction. As Li and Thompson (1977) have pointed out, the copula of Mandarin *shi*, originated from the demonstrative prononun, which was reanalyzed as a copula when the topic grammaticalized into a subject, the topic-comment construction thus becoming a subject-predicate contruction (cf. also Baker, 2003)

In a graph theoretic perspective, more broadly, the assumption that a syntactic element could be interpreted as a *linker*, implies the theoretic necessity that certain linguistic items could be selected by the lexicon as *Edges* (E), instead of *vertexes* (V). (Cf. Chapter 3). This point will be discussed in Chapter 5.

Adopting the perspective introduced above, the Ezafe morpheme could be interpreted just as the French item *de* (81-4b) and Thai *thˆıi* (82-4b), as discussed in Den Dikken and Singhapreecha (2004). See the following examples given in their article:

French

(81-4) a. une pizza chaude
a-fem pizza hot-fem

b. une pizza *de* chaude
a-fem pizza *de* hot-fem
Both: "a hot pizza"

Thai

(82-4) a. khon ken
person smart

b. khon *thˆıi* ken
person *thii* smart
Both: "the/a smart person"

According to Den Dikken and Singhapreecha in French and Thai the *NP-linker-AP* constructions receive a contrastive interpretation and *NP-linker-AP* constructions have also AP represent old information [topic] (whereas in their linker-less counterparts, AP represents new information [focus]).

Considering the fact that in Persian constructions like AP-NP or an NP-AP (without a linker) are (almost) absent, we may say that the interpretational *shift* raises a *Generalized Predicate Inversion*. The constituent preceding the Ezafe morpheme in the Persian noun phrase is, in fact, the subject of the inverted predicate, which tells us that, just as in French and Thai, the word-order effect of Predicate Inversion is *undone* later in the derivation *via* raising of the subject to the Specifier of a higher functional projection whose head is empty in the base and is reached by the linker as it raises.

The relevant thing in this traditional perspective is that Predicate Inversion gives rise to the emergence of a linker element in a functional head position whose specifier serves as the landing site of AP-raising and the word-order effect of Predicate Inversion is undone at a subsequent point in the derivation, when NP raises around AP into the specifier of a Classifier Phrase (and the fact that Persian has many distinct classifiers could lead to an interesting work of "fine cartography").

The linker concomitantly raises to the head of this Classifier Phrase; the *net* result is NP-linker-AP, as desired.

In a graph theoretical perspective, on the contrary, the present analysis is stimulating and fascinating because we are induced to assume that some items are selected by the Lexicon as edges, instead of vertexes (in example *functional* items: see chapter 5).

Now, I introduce some facts about inverse predication in the DP and then I will propose the graph analysis of Ezafe.

4.4.1 More things about predicate Inversion in DP

Predication is not in any way restricted to the sentential domain: one finds predication inside noun phrases as well, as for instance in the relationship between adjectival modifiers and the nominal heads of complex noun phrases. And because predication *per se* is *omnipresent*, there is no particular reason to expect Predicate Inversion[91] and the concomitant emergence of

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[91] Let's take the following examples to introduce briefly Moro (1997) theory of Inverse Predication

(i) una foto sul muro fu la causa della rivolta
a picture on the wall was the cause of the riot
(ii) la causa della rivolta fu una foto sul muro
the cause of the riot was a picture on the wall

According to the standard analysis:
• The subject of the small clause is what raises to the clausal subject.
• (i) and (ii) are syntactically parallel.

But, Moro points out this is not the case. One example is the "asymmetry" of post-verbal DP extraction.

(iii) [quale foto sul muro]$_i$ pensi che t_i fu la causa della rivolta?
[quale foto sul muro]$_i$ pensi che la causa della rivolta fu t_i?

Based on this and other asymmetries in English and Italian, Moro (1993, 1997) proposes that the standard analysis is incorrect. Both (i) and (ii) are derived from the same merge structure. The two different sentences arise depending on whether 'the girls' (a canonical copular) or 'the cause of the fight' (an inverse copula as in (ii)) raises to spec TP.

linker elements to be restricted to the sentential domain, either.

Indeed, Den Dikken (1995; 2005) shows that Predicate Inversion and the linker elements that they depend on, do show up elsewhere—inside *complex noun phrases* in particular. Example (83-4), taken from Den Dikken (2005: 174) is a good illustration of Predicate Inversion inside the complex noun phrase. Clearly, we understand (83-4) in such a way that there is a relationship of predication between *jewel* and *island* - more specifically, we understand (83-4) to mean that the property denoted by jewel is predicated of island (the island is like a jewel), not the other way around (cf. Den Dikken, 2005). In other words, underlyingly *jewel* is the predicate of *island*, the two of them starting out in an Small Clause of the type in (84-4a); but they do not preserve their underlying order. The predicate is inverted around its subject (84-4b), and, concomitantly, we see a linker element emerge: *of*.

(83-4) a jewel of an island

(84-4)
a. $[_{SC}$ [an island] [jewel]]
b. $[_{DP}$ a [jewel$_i$ [of $[_{SC}$ [an island] [t_i]]]]]

With (83-4) analyzed as a case of Predicate Inversion inside the complex DP , the obligatory use of a *meaningless* (cf. Den Dikken, 2005) element *of* can be made sense of immediately: *of* is a linker, the DP-internal counterpart of the copula (cf. also Larson, 1991). Let's briefly sketch the *schemata* adopted in Den Dikken (2005: 178):

(84-4)
a. $[_{RP}[_{XP}$SUBJECT] [RELATOR $[_{YP}$PREDICATE]]] (*Direct predication*)
b. $[_{FP}$[PREDICATE]$_j$ $[_{F'}$ LINKER+RELATOR$_i$ $[_{RP}$[subject]$[_{R'}$$t_i$ t_j]]]] (*Inverse predication*)

So, we could say - as already stated - that the Generalized Predicate Inversion in the Persian complex noun phrase is marked by the appearance of the Ezafe morpheme, an element that we are, thus, guided to analyze as a *linker* along the lines of Den Dikken and Singhapreecha (2004) and, in a

Asymmetries are accounted for by the fact that the movement of the DP which ends up as the subject of the main clause has different sources.Predicate Inversion is an A-movement operation that inverts the underlying order of subject and predicate by raising the latter across the former (Moro 1997). This A-movement process is contingent on the presence of a linker in the syntactic structure (Den Dikken 1995) and produces a predicate-linker-subject structure in which the predicate serves as a *topic* (old information).

canonical framework, using the underlying representation in (84-4).

Here is a proposed derivation for a Thai example taken from Den Dikken and Singhapreecha (2004: 19-20):

(85-4)

a. roˆm *t^h^ii* ja`j saˇam k^han na´n
umbrella *thii* big three clf dem
'those three big umbrellas'

b.

i. [$_{SC}$ NP AP]
-> merging F; AP-to-Spec,FP (PREDICATE INVERSION), with Spell-Out of F as LINKER *t^hˆıi* ->

ii. [$_{FP}$ AP$_a$ [*t^hˆıi* [NP t_a]]]
-> merging Clf1 (null); REMNANT MOVEMENT to Spec,Clf1P + *t^hˆıi* -to-Clf1 ->

iii. [$_{Clf1P}$ NP$_i$ [*thˆıi*$_x$ [$_{FP}$ AP$_a$ [t_x [t_i t_a]]]]]
-> merging Q (= *saˇam*); Clf1P-to-Spec,QP ->

iv. [$_{QP}$ [$_{Clf1P}$ NP$_i$ [*thˆıi*$_x$ [$_{FP}$ AP$_a$ [t_x [t_i t_a]]]]]$_j$ [*saˇam* t_j]]
-> merging Clf2 (= *khan*); QP-to-Spec,Clf2P ->

v. [$_{Clf2P}$ [$_{QP}$ [$_{Clf1P}$ NP$_i$ [*thˆıi*$_x$ [$_{FP}$ AP$_a$ [t_x [t_i t_a]]]]]$_j$ [*saˇam* t_j]]$_k$ [*khan* t_k]]
-> merging D (= *na´n*); Clf2P-to-Spec,DP ->

vi. [$_{DP}$ [$_{Clf2P}$ [$_{QP}$ [$_{Clf1P}$ NP$_i$ [*thˆıi*$_x$ [$_{FP}$ AP$_a$ [t_x [t_i t_a]]]]]$_j$ [*saˇam* t_j]]$_k$
[*khan* $_{tk}$]]$_m$ [*na´n* t_m]]

In Thai, in the course of the derivation of complex noun phrases with the linker *thˆıi*, as we may see in (85-4b) the AP inverts around its subject, ending up in the *specifier* position of a functional projection. The next step in the derivation involves raising of the *remnant* around the fronted AP, to the specifier position of Clf1P, whose head, under Den Dikken and Singhapreecha (2004) analysis, here, is base-generated empty. This step involves the skipping of a specifier position: that of FP, which AP was raised into. To make this legitimate, the head of FP, which is *spelled out* as *thˆıi*, has to raise to the head position of Clf1P. The interim result of the derivation is a word order in which, as desired, the NP precedes *thˆıi*, which in turn precedes AP.

For our purposes, the relevant step in the derivation is this one: the raising of the remnant across the raised AP, into Spec,Clf1P, with concomitant raising of *thˆıi* from F to Clf1.

This step (arguably triggered by the need for Clf1 to check a feature for/against NP) is responsible for the restoration of the relative order of NP and AP and takes the *linker* up into a position directly in between NP and AP. Thus, we have the following word order: NP-linker-AP. (Cf. Den Dikken and Singhapreecha, 2004: 22)[92].

4.4.2. The graph analysis of Ezafe

Let's propose a graph analysis in (88-4) for the following basic example:

(86-4) . fill (*.) e . abi (. inj-ast)
elephant-Ez blue (here is)
"the/a blue elephant is here"

A representation, according to Den Dikken and Singhapreecha, and based on (86-4) would be:

(87-4)
a. [$_{SC}$ NP AP]
-> MERGING F; AP-to-SpecFP (PREDICATE INVERSION), with
SPELL-OUT OF F as LINKER *Ez* ->

b. [$_{FP}$ AP*a* [Ez [$_{SC}$ NP *ta*]]]]
-> MERGING Clf (null); REMNANT MOVEMENT TO SpecClfP +
Ez-to-Clf ->

c. [ClfP NP*i* [Ez$_x$ [FP AP$_a$ [t_x [t_i t_a]]]]]

[92] Note that this approach *prompts* an analysis of relative-clause constructions that recognizes relative clauses as *predicates* of DP-internal small clauses, combining the attractions of the traditional approach and the Vergnaud/Kayne raising approach by assigning relative clauses an internal structure similar to the traditional one while giving it the external distribution of a predicate by treating it as the predicate of a noun phrase-internal small clause.

Instead, in a graph based account (cf. chapter 3) - established that we have to *play well* only with items from the lexicon and the relations among them - it is necessary to assume that there are items [such as the Persian Ezafe] that are introduced as edges (marking a relation, enhancing an operation between two adjacent vertexes) and reducing the computational complexity.

(88-4)
a . fill (<u>e</u>) . abi

b.G1=(V1, V2): V1={*fill*}, E1=∅
G2=(V2, E2): V2=∅ , E2={*Ez*},
G3=(V3, E3): V3={*abi*}, E3=∅

b. MERGE(G1, G3) = G4=(V4, E2)
Where V4=V1∪V3={*fill, abi*}
And E2= {*Ez*},

.fill $\overset{Ez}{\overline{\qquad\quad}}$. abi

The hypothesis that an edge is already present within the lexicon has an interesting appeal, at least for the *economization* of syntactic operations. As we have seen in (88-4), indeed, a *dummy* element such as the Ezafe (that it is not so dummy, given its meaning: *add*), is only the phonological *ouvert* feature of an edged-relation between two lexical items (vertexes).

The most obvious consideration that one could make against such an approach is that it does not explain any other (*specific*) syntactic constraint. But, that is the point: it would be too easy, in my opinion to formulate a rule *=insert Ezafe* to justify the process of parsing. For example, one could introduce a *categorial* criterion (spreading a list of cross-linguistic examples: from French to Thai, from Chinese Mandarin and Romanian) as the following:

In the noun phrase domain the graph allowed is the directed graph going from N to A, when an Inverse Predication occur and the edge (the linker) is spelled out.

I believe, instead, that an economical syntax should avoid to make extensive use of categories. Maybe, the only distinction available in our Language Organ is between functional and lexical elements.

This in one of the possibilities: another possible, graph induced, distinction could have been - given an "edge status" to some items - between *vertex-items* and *edge-items* (intuitively determiners, verbs and complementizers would be edges; referential items vertexes), avoiding even the need of a set of relations (the relations would be *subsumed* in the Lexicon in this way). I think that the second option is irrational, and no language (natural or artificial) can be computed in that way.

On the contrary, the first possibility is somewhat stimulating and I will try to make an articulated discussion of the consequences of a proposal of this kind in the following chapter.

5. Some theoretical issues and implications

In this chapter I will *lay* some possible theoretical foundations, based upon the representational investigations made in the third chapter of this work, and assumed for of the analysis of Ezafe in the fourth chapter.

5.1. On the possible "Edgeness" of functional items

As I have postulated in the last paragraph of the previous chapter - mainly based on the syntactic analysis of Persian - some items of the lexicon may be selected as *edges* instead of *vertexes*. The presence of the Ezafe morpheme as a *linker* in Persian noun phrases has been our first empirical example (interpreted in the vein of Den Dikken and Singhapreecha (2004)). This observation leads to a strong similarity with the representation of *chemical structures* (going far beyond the metaphor of Baker (2001)), as we will see (lying) pervasively in the present section.

However, the very interesting fact is that this kind of observation could be assumed as the *ground* for an empirical (weak) generalization that has several consequences for the study of syntax in a graph theoretic perspective:

The only items that may be structurally (not pragmatically) deleted in syntax are functional items (in example complementizers, prepositions or postpositions, determiners, copulas, linkers). Functional items are represented as edges. Thus, while a vertex (a lexical item) has necessarily a phonological content, an edge may be pronounced or not.

I assume that, in a graph theoretic perspective, this is one of the fundamental observations concerning the empirical *parametric* differences across natural languages. Many examples will follow, with the aim to contextualize this simple, yet hopefully not trivial deduction.

An unconscious *trigger* for this issue has been represented by the powerful Lewis formulas (definitely, a sort of *directed graphs*), commonly used for the *schemata* of chemical elements and molecules[93]. As we will see in depth as a metaphor, but as we may intuitively introduce here, lexical items (such as nouns, verbs or adjectives) may be seen as protons inside a nucleus, while functional items as electrons that exist outside of the nucleus in areas of high probability (but without *spatial* substance) called *orbits*, or *shells*. Again,

[93] Notice that the discover of the deeply important chemical phenomenon of *isomerism* has been anticipated by the graphical notations of Crum Brown in the 1850s.

(*fuzzy*) topology plays a crucial role.

Our hypothesis represents an economical way to explain some of the parametric (or, say, typological) differences of many languages (in example the absence (vs. presence) of determiners (as in the Slavic languages or Chinese Mandarin) or the absence (vs. presence) of copula (as in Russian or Chinese Mandarin).

5.1.1. On the different status of lexical vs. functional items

In some way, a preliminary theoretical *X'—Theory* ground for my assumptions could be found in the seminal work of Fukui and Speas (1986). They suggested that the projections of lexical heads L° are recursively iterable L's[94], while the projections of functional heads F°s are non iterable F' (these projections are driven in example by the discharge of F°s unique *subcategorization* feature onto the complements of F°s) and closed F'' (being this projections driven by the discharge of a unique *agreement* feature onto a maximal projection that moves into the (necessarily) unique Spec position). Therefore, given the *relativized* X-Theory of Fukui and Speas (1986) any functional head has a *lonely* complement (sister to F° and dominated by F')) and (at most) one specifier (sister to F' and dominated by F''), who agrees with F° and closes off the F'' projection.

5.1.2. The ontology of functional items

Functional items are necessarily non-productive closed classes. Taking their *innermost* nature as an issue for the discussion, it is possible to say that they lack a descriptive content. As argued in the groundbreaking work of Abney (1987):

> "Their semantic contribution is second order, regulating or contributing to the interpretation of their complement. They mark *grammatical or relational* features, rather than picking out a class of objects". (Abney 1987: 65).

I hope this point could be useful for my proposal. Functional items are *edges* in a graph based syntactic model just because they are relational items, without a specific weigh (or, at some level, a *referential* nature)[95].

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[94] In Fukui ans Speas (1986) reinterpretation of X'-Theory these projections are driven, for example, by the discharge of theta features or subcategorization features.

[95] I think that categories are not unitary notions, but emerge at the interface of different

Take Persian Ezafe as an example. As a functional morpheme in what is canonically assumed to be the nominal "domain", such an item is useful to specify a *reference*. In more general terms, a noun provides a *predicate*, while a determiner "picks out a particular member's of the predicate's extension" (Abney 1987: 76).

Furthermore von Fintel (1995) argues that functional morphemes have a l*ogical-relational* (for example permutation-invariant) semantics:

"Logicality means insensivity to specific facts about the world, suggest a purely mathematical relationship" (von Fintel, 1995: 179)

5.2. Case: from Government and Binding to Graph Theory

Even though only pronouns show overt morphological case in languages such as Italian (i.e *io* vs. *me*) or English (*I* vs. *me*) - taking as a starting point the Government and Binding (GB) Paradigm (cf. Chomsky, 1981; Haegeman, 1996) - it is widely assumed that all NPs have Case (called *abstract* Case) that matches the morphological Case that shows up on pronouns. Appeal is made to other languages with much richer case systems than Italian or English to "back up" this claim.

Reviewing the basis of GB Case Theory we may observe that (in phrase structure terms):

a. Nominative Case is assigned to the NP specifier of I[+*fin*] such as in (5-1).

(5-1)

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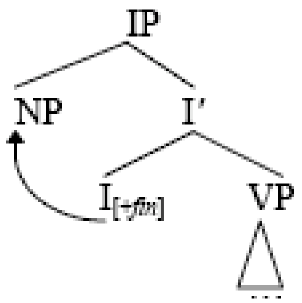
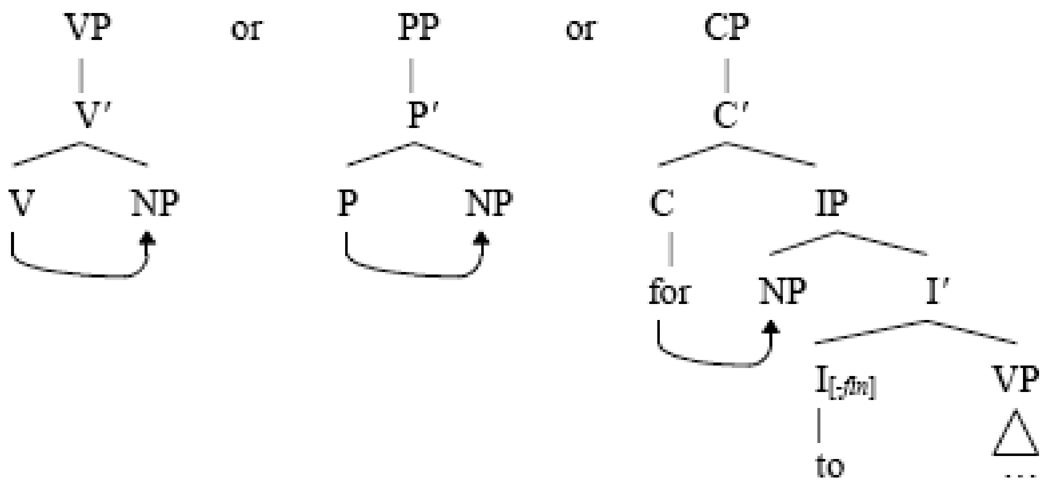
components of human cognitive and communicative capacities (cf. Muysken, 2005).

Categories are far more ambiguous than a commonsensical view could assume. Cross-linguistically, there is an infinite series of examples concerning categories under-specification, overlapping phenomena (cf. Comrie *et al.* 2005) and there is also an Indonesian language claimed to be (almost) mono-categorial (cf. Gil, 2001). Note also that in recent years, within the generative framework, Marantz and other researchers coming from *Distributed morphology* paradigm take a strong stand (in many, still unpublished papers) and propose that basically all lexical categories (nouns, verb, adjectives) are formed in a similar manner from category-less roots. This claim predicts that we should find productive triplets (noun, adjective, verb) of every category-less root (cf. Marantz, 2001).



b. Accusative case is assigned to the NP sister of V or P. The C[*for*] which is homophonous with the preposition for acts like P for Case assignment. Note that the subject of a non-finite clause could not receive Case from I[-*fin*] since only I[+*fin*] assigns Nominative Case.

(5-2)



c. Genitive Case, finally, is simply assigned to the specifier of N.

What is the same about these positions that *receive* Case and the positions that *assign* Case? Chomsky observed that every maximal projection (=XP) that dominates the NP that receives Case also dominates the head that assigns it (at least, if we do not count the IP that intervenes between the C[*for*] and the NP).

A (*rough*, avoiding the notion of c-command) definition of government comes from this observation:

a GOVERNS *b* iff

a. *a* is a head [±N,±V] or I[+*fin*] or C[for], and
b. every XP that dominates *a* also dominates *b*, and
c. every XP (other than IP) that dominates *b* also dominates *a*.

In this definition, *a* and *b* stand for particular categories. Proposition (a) requires that *a* is one of the heads N, V, A, P, I[+*fin*] or C[*for*]. Almost always, *b* is an NP, since are nouns that need Case (which is assigned under the government relation). Proposition (b) determines how high up the tree a head may govern: if every maximal projection above the head must also dominate the NP in question, then the NP must be below the maximal projection of the head (e.g. VP for V, IP for I[+*fin*]). Proposition (c), finally, provides the lower limit of government by not allowing the head to govern *down* into another maximal projection other than IP.

Together, Proposition (b) and (c) establish *locality* constraints on the government relation for each head (cf. Rizzi, 1990; Manzini, 1992).

The Case assignment rules in terms of government are *quite* simply ad elegant. Referring to the structures represented above we may say that:

a. I[+*fin*] assigns nominative case to the NP specifier that it governs.
b. N assigns genitive case to the NP specifier that it governs.
c. V, P, C[*for*] assign accusative case to the NP that they govern.

GB requires that all NPs must have Case at S-structure by the Case Filter (Cf. Haegeman, 1996).

CASE FILTER: **NP if it does not have Case at S-structure.*

With one further assumption, we will have the motivation for A-movement in passive, unaccusative, and raising constructions (Cf. Zamparelli, 1995-2000). The famous Burzio's Generalization (Burzio, 1986) states that predicates which do not assign a semantic role to their external argument cannot assign Case to their complement(s). This provides the answer to why the passive object must (cross-linguistically, *can*) move.

In GB, passive verbs do not assign a semantic role to their external argument position, so they have *lost* the ability to assign Case to their complement.

Therefore, the NP object cannot remain in place at S-structure and must move to a position where it can get Case: the *specifier* of I[+*fin*] where nominative case is assigned. The same observation accounts for the unaccusative and raising constructions: the NP which cannot receive Case in its (*Deep structure*) position is the one which must move; and it may only move to a position which does assign Case, the specifier of I[+*fin*].

Now, it is interesting to notice that, contrary to GB assumptions, more recent researches (Bittner and Hale, 1996; Chomsky, 1998) assume structural Case as a *syntactic feature* that is *incapable* of inducing movement. Thus, Case gets checked (erased) as a result of structural factors that exist independently of Case itself. In the Minimalist Program, Chomsky argues that Case-checking is "ancillary" to other feature-checking mechanisms.

I assume that, cross-linguistically, Case morphemes, revealing a relation between items in what we may continue to call a clause (or in a phrase: see Case marked adjectives), are *functional elements that may be represented as edges*. A trivial proof is that natural languages make extensive use of prepositions (other available functional elements) where Case morphology is not a given syntactic possibility.

Thus, morphological Case on nominals is a common *device* to express the syntactic (and semantic) relationships between clausal constituents. However, it is important to remark that the languages of the world that use this strategy vary greatly with respect to the number of Case categories represented in their inflectional system.[96]

A problem, concerning the GB paradigm, is that if we assume a fine structure of the inflectional phrase (cf. Pollock 1989; Belletti, 1990), and according to Chomsky and Belletti we refine the observation in (5-1) saying that "NP is nominative if governed by Agr", many cross-linguistical data, such as Japanese and Icelandic *quirky subjects* (Ura, 2000; Sigurdsson, 2002) or split-ergativity patterns (i.e. *agreement* vs. Case), such the ones in Georgian *aorist* (cf. Harris, 1981; Marantz, 1984; Comrie, 1989) raise objections. See the examples below:

[96] The minimal Case paradigm contains *two* members, since paradigmatic relationships between word forms are ultimately based on binary oppositions (*minimal pairs*). This implies that whenever a language has an overtly marked Case category expressing a specific function, a corresponding zero-marked base form is counted as a Case (the "default case" or "direct case") even if it has non-specific function describable in *positive* terms. In such instances, the base form receives its case status only by virtue of contrasting with a *functionally* (and *formally*) marked Case category. An example, given in the World Atlas of Language Structures (edited by Comrie *et al.* 2005), is Mapudungun (Araucanian; Chile), which has only one overt case suffix *-mew* ~ *-mu* expressing diverse *oblique* functions such as place, cause, and instrument. On the other *vertex* of the continuum there are languages which show very large paradigms. The languages with the largest paradigms, again according to the World Atlas of Language Structures, are Hungarian with (under some analyses) 21 productive cases, followed by Kayardild (Tangkic; Queensland, Australia) with 20, and Lak (Nakh-Daghestanian; eastern Caucasus, extensively studies at Max Plank Institute Department of Evolutionary Anthropology) with 19 cases. (Iggesen, 2005).

Japanese

(5-3) a. Taroo-ni hebi-ga kowa-i (Ura, 2000)
Taroo-Dat snake-Nom fearful-Pres
"Taroo is fearful of snakes"

b. Taroo-ni eigo-ga dekir-u
Taroo-Dat English-Nom understand-Pres
"Taroo understands English"

As we may observe easily, dative NP in the examples above in (5-3a,b) behave as subjects (in example, they can bind subject oriented anaphors).

A similar *quirkyness* is shared by Icelandic:

Icelandic

(5-4) Mér var hjàlpaò (Sigurdsson, 2002)
Me-dat was helped
"I was helped"

(5-5) a. Akur leiddist
Aki-dat bored
"Aki was bored"

b. Akur virtist hafa leiddist
Aki-dat seem to-have bored
"Aki seemed to have been bored"

c. Viò töldum Akur hafa leiddist
We believe Aki-dat to-have bored
"We believe Aki to have been bored"

Icelandic quirky Subjects, summarizing a survey made up by Sigurdsson (2002), have been tested for reflexivisation, ECM infinitives, Raising, Control etc. Some examples have been given in (5-5).

Furthermore, a so-called *split-ergativity* due to the *tense/aspect* specification of the clause is found *somewhere*. Basic facts concerning the relation between Case and agreement are illustrated in the following examples. Georgian is well-known for its split-ergativity of this kind[97]. In Georgian, for example, the aorist tense system demands ergativity and the present tense system demands accusativity (*data* are from Comrie, 1978 and Lyle, 1997, cited in Ura, 2005; cf. also Harris, 1981).

Georgian

(5-6)

a. PRESENT

SUBJ in transitive: Nominative + subject agreement
SUBJ in unergative: Nominative + subject agreement
SUBJ in unaccusative: Nominative + subject agreement
OBJ in transitive: Accusative + object agreement

b. AORIST

SUBJ in transitive: Ergative + subject agreement
SUBJ in unergative: Ergative + subject agreement
SUBJ in unaccusative: Absolutive + subject agreement
OBJ in transitive: Absolutive + object agreement

Geogian

(5-7)

a. PRESENT

a′. Student-i midis. *Intransitive*
student-NOM go(PRES)
'The student goes.'

a′′. Student-i ceril-s cers *Transitive*
student-NOM letter-ACC write(PRES)
'The student writes the letter.'

[97] Besides Georgian, Hindi and many other Indo-Aryan languages, Burushaski, Tibetan, Nepali, Samoan, etc. show similar split-ergativity due to the tense/aspect specification of the clause (see Comrie 1978; Dixon, 1994, and Palmer, 1994 for a list of such languages).

b. AORIST

b′. Student-i mivida. *Intransitive*
student-ABS go(AOR)
'The student went.'

b′′. Student-ma ceril-i dacera. *Transitive*
student-ERG letter-ABS write(AOR)
'The student wrote the letter.' (from Ura, 2005)

Although it is a well-known fact that agreement in Georgian is extraordinarily puzzling and highly resistant to a systematic explanation, the data in (5-6) and (5-7) reveal the weakness of GB assumptions about Case, showing a *discrepancy* between abstract Case and Case morphology / agreement.

In brief, the set of data presented here means that Case morphology is not a systematic reflex of *abstract* Case.

We may argue that Case has not to be viewed under *licensing*, or *filtering,* but it is instead Case that *interprets* syntax and expresses a relational feature (at PF level).

Anyway the feature values are largely *self-explanatory*. In languages lacking morphological case[98], grammatical relations are expressed by word order and/or morphologically and prosodically independent function words (generally, prepositions and postpositions), and partly also by morphological *devices* on the verb. Here are some cross-linguistic examples concerning what, following and partially revising Comrie (1989), we may call the *Alignment of (Structural) Case Marking*:

i. No morphological case

Thai

(5-8) phom kin khaw
I eat rice
"I eat rice"

[98] Remember that in these languages, the default form receives its Case status by pairing it with functionally and formally Case-marked categories.

Chinese Cantonese (Van Valin 2003: 39)

(5-9) a. Ngóh/ngóhdeih jengyi kéuih/kéuihdeih.
1sg /1pl like 3sg/3pl
"I/we like him~her/them."

b. Kéuih/kéuihdeih jengyi ngóh/ngóhdeih
3sg/3pl like 1sg/1pl
"He~she/they like(s) me/us."

c. Jek maau gin léuhng jek gáu.
cl cat see two cl dog
"The cat sees two dogs."

d. Léuhng jek gáu gin jek maau.
two cl dog see cl cat
"Two dogs see the cat."

Note that the *neutral* system is widespread across the world. While it might be expected in areas that *otherwise* have little morphology, such as South-East Asia and West Africa, it is in fact also found in languages that have complex inflectional morphologies, but where such morphology is largely confined to the verb, as, for instance, in Bantu languages and several languages of the Americas (cf. Iggesen, 2005 for a detailed survey).

ii. Nominative / accusative

Latvian (Mathiassen 1997: 181)

(5-10) a. Putn-s lidoja.
bird-nom fly.pst.3
"The bird was flying."
b. Bern-s zime sun-i.
child-nom draw.pres.3 dog-acc
"The child is drawing a dog."

We must notice also – regarding the nominative-accusative pattern - that there are languages, such as *our* Persian or Hebrew, in which *definite* objects are case marked, but not *indefinite* ones.

iii. The ergative / absolutive pattern

A preliminary remark: the ergative/absolutive (or simply: ergative) pattern is one that treats the agent of transitive verbs distinctly from the subject of intransitive verbs and the object of transitive verbs[99]. See the following examples for Hunzib (Nakh-Daghestanian; eastern Caucasus):

Hunzib (van den Berg 1995: 122)

(5-11)
a. kid y-ut'-ur
girl cl2-sleep-pst
"The girl slept."

b. otdi-l kid hehe-r
boy-erg girl hit-pst
"The boy hit the girl."

In a number of languages, the case-marking system is different in different *tense-aspect-moods* (cf. Comrie, 1978; 1989). We have already seen that in Georgian (5-6; 5-7), there are different sets of tense-aspect-moods with respect to the fine details of case marking, grouping into (al least) two sets with respect to the factors relevant to present concerns. In the *Aorist* series, case marking is on an active–inactive basis. However, in the *Present* series, it is on a nominative–accusative basis (see *above*).

In some languages, a case marker is used primarily to avoid ambiguity, so that in Lower Grand Valley Dani (Trans-New Guinea; Papua, Indonesia; cf. Bromley 1981: 84–5, cited in The World Atlas of Language Structures, henceforth: tWAoLS), for instance, the ergative marker is used in this way. In yet other languages, case markers are described as optional, without any detailed discussion of the conditions under which the marker does or does not occur[100].

According to various authors (Comrie 1989; Dryer, 1992), more complex patterns may arise, such as in Gooniyandi (Bunaban; Australia) where the

[99] I suggest to read for further details a recent and interesting volume *Ergativity: emerging issues*, edited by Massam *et al.* (2005) and published in the *Natural Language and Linguistic Theory Studies* series.

[100] This is the case of the accusative marker in Burmese or the ergative marker in Araona (Tacanan; Bolivia; Pitman 1980: 14).

ergative marker is optional with animate nouns, but obligatory with inanimate nouns (McGregor 1990: 319–20, cited in tWAoLS; Iggesen, 2005).

One of the most unusual ways of expressing case is found in Maasai, a Nilotic language spoken in east Africa; in this language it is the tone on the last syllable of a noun which indicates whether it is nominative or accusative (Welmers, 1973, reported in Van Valin (2003: 48).

Maasai (Welmers, 1973)

(5-12)

a. Cile pòntét. (Maasai)
Look-at old-man
"He's looking at the old man."

b. Cile pòntet.
Look-at old-man
"The old man's looking at him."

In (5-12a) there is a high tone on the last syllable of the noun, and this signals that it is the direct object of the verb, while in (5-12b), the absence of a high tone on the last syllable of the noun signals that it is the subject of the verb.

Among a million of Case puzzles, we choose now a little *familiar* example: a minimal inter-linguistic structural *shift* in the domain of Romance Languages, specifically regarding Spanish *vs*. Italian accusative device:

Spanish

(5-13)

a. María vio *a* Juan.
Mary see.pst.3sg acc John
"Mary saw John."

Italian

b. Maria vide *ø* Gianni
Mary see.pst.3sg acc John
"Mary Saw John"

How can a standard GB representation accounts for this fine-grained structural discrepancy? Well, we may say that in (standard[101]) Italian is V that assigns accusative Case to its sister NP, while in Spanish is P that assigns accusative Case to the NP that it governs. This could be a logical solution, but my *remnant* question is: *Why have we to assume different structures for the same linguistic relations?*

Graph theory may capture the cross-linguistic *continuum* introduced above in an economical way, assuming the simple device represented below. This minimal cluster will be explained broadly in the following section:

(5-14)
v ___e___*(v)*_ _ _

The simple representation in (5-14) implies that lexical items in a (strong) graph-based theory are vertexes (regarding morphologically Case marked items, we may use the term *lexical stems*), while Case markers (affixes, suffixes etc.) are (*floating*) edges, signalling a relation between (among) *core*-lexical items. The same apparatus could be valid for a basic explanation of agreement features. Notice that unlike other formal *features*, Case is considered by many authors to be "the pure un-interpretable feature *par excellence*" (Chomsky 1995: 278-279). For example, it is not considered to have an *interpretable* counterpart with which it is matched in some minimal domain (an empirical objection may be found in paragraph 5.2.2).

In brief, my (empirically driven) proposal, involving syntactic graphs is:

An edge could be presupposed at (what we may continue to call) PF, a vertex no.

A cross-linguistic *test* for determining the contexts / items subject to deletion (*presupposition at PF*) may be useful. Some examples will be given in the course of the present chapter.

Before discussing the consequences of my hypothesis I want to point out an interesting fact. It is quite interesting to underline the following empirical evidence: pronouns in many languages have a different Case-marking system

[101] Many Italian dialects such as, for example, Sicilian allow for the Spanish *model*:

(i) Salvo nun vitti a Maria:
Salvo not see.pst.3sng Acc Mary
"Salvo did not see Mary"

from full noun phrases.

In English or Italian, for instance, as we have already seen, while full noun phrases have a neutral Case marking system, pronouns have a nominative–accusative system (a trivial example: *we* vs. *us*). There must exist a *criterion*, namely the assignment of some *weight* to differentiating pronouns from full noun phrases. Sometimes the problems that occur with full noun phrases occur with somewhat *less force* in the case of pronouns; for instance, several languages where full noun phrase object-marked *sometimes* take an accusative marker and *sometimes* not, require pronouns to take this marker (the example that I have in mind is, *as always*, Persian), so that there is no hesitation in assigning them to the nominative–accusative type with respect to case marking of pronouns.

Naturally, as other functional categories, pronouns can be null items (that is in *pro-drop* linguistic domains), thanks to the feature driven values (or *edge-relational legacies*) of natural languages.

The most authoritative view of null subjects (and, consequently, pronouns-deletion) within the Principles-and-Parameters / GB framework - in particular as found in languages (Italian, for instance) with rich subject-verb agreement - is the one articulated by Rizzi (1986), building on earlier work by Chomsky (1981), Rizzi (1982), among others: in Rizzi's view the null subject is an empty pronominal, (little) *pro*, inherently unspecified for ϕ–feature values. The distribution of *pro*, elegantly, is determined in the Rizzi's view by the following two conditions:

(5-15)
a. *pro* must be licensed.
b. *pro* must be identified.

The simple, yet very deep theory of Rizzi (1986) can explain the well-known correlation between rich agreement morphology and null subjects: in languages with weak agreement morphology Inflection fails to license *pro*. It may also fail to identify *pro*. However, the theory accounts for the possibility that a language can identify *pro* in some persons (for instance 1*st* and 2*nd* person plural in French, within the domain of Romance Languages), yet never allows null subjects.

This theory of null subjects cannot be maintained if we accept a theory making a distinction between interpretable and un-interpretable features, as proposed by Chomsky (1995). Chomsky argues that there are two varieties of ϕ–features: an interpretable and an un-interpretable specie. The person, number and gender features of an NP (or DP) are interpretable, restricting the denotation of the NP. The person, number, or gender features which appear on a verb, auxiliary or adjective are *un-interpretable* as they do not restrict the denotation of these categories. By definition un-interpretable features cannot survive until LF, so they must be eliminated in the course of the derivation of LF. However, they may be, and typically are, visible in PF. According to Chomsky 2000, 2001a, 2001b their role in the grammar is to *drive* syntactic operations, particularly movement (cf. Holmberg, 2005 for a more articulated discussion).

This kind of "implied directionality" of *features*, in the latest Chomsky's proposals is assumed as a substantial *stroke* in the syntactic graph theory under development here, because as I have underlined already in (the third chapter of) the present work *Syntactic graphs are directed, edge labelled graphs*. The directionality of graphs, and the directionality of features *along* edges (for the limitations of our physical nature, the linguistic signal is obviously directional) implies asymmetry just as a subject-predicate relation in traditional (and generative: see the recent assumption in Den Dikken, 2005) grammar do.

5.2.1 A revised, enhanced version of the Graph syntactic model

In Chapter 3 we have given a graph theoretic account based mainly on two milestones: Chomskyan bare phrase structure and a (revised/simplified) version of the most prominent (according to the recent literature) syntactic operation: *Merge*. In more precise words I assume that Merge (X,Y) is (5-16a) instead of (5-16b).

(5-16)
a. Merge (X,Y) = { X,Y }
b. Merge (X,Y) = {X, { X,Y }}

In such an account, which follows the *pioneeristic* work of Collins (2002) it is not possible to formulate operations that refer to labels (in example PP vs. DP) or bar-levels (in example DP vs. D′). The work that I have done in Chapter 3 was to make a formalistic *shift*: from the standard X′-bar representations to *directed graphs* without bar-levels or categorial projections (passing through Chomsky's (1993) *Bare Phrase structure*). We have seen that we may find a more economical way to express syntactical relations, and I suppose that this result, in the general philosophical background of the

Minimalist Program, is an interesting fact.

A theory could be developed on the basis of this formalistic shift. The theory in question must obviously be strictly local (in the sense of Collins, 1997). *Adjacency* is a critical matter in syntax: in a graph based model I think that it must be required as a trigger for syntactic operations.

In the following pages I will outline the prolegomena (or, better, the prolegomena of the prolegomena) of a graph based syntactic theory. Many of the principles given here must be empirically, cross-linguistically tested (a *titanic* work): they are assumed here as a derivational *path* built on a representational model.

The result reached in chapter 3, as an input for a formalistic translation from X'-Theory to another syntactic (topologically oriented) representation, I hope can *yet* represent an interesting experiment and a result.

One way to think about out mental lexicon is to say that it contains words belonging to various categories; syntactic units are the items manipulated by the computational mechanisms; these units are the items that may be copied, deleted or indexed.

As I anticipated at the end of chapter four, I am not sure of the necessity of postulating a set of categories in a *derivational* computation of clauses. Probably a minimal pair of items of this sort {functional, lexical} is sufficient for all the operations that the *Language Organ* sets up.

I am not a visionary (I hope so) when I propose this kind of an approach. The incredible set of linguistic possibilities in the way to express lexical categories is attested, even considering only the generative paradigm, in the works of Mark Baker (1988, 2003), which is definitely a *leading* linguist. Going back to other linguistic adventures we may see that John Ross (1972) theorized a *Category squish*, in the (too fast forgotten) paradigm of Generative Semantics and Labov (1977) made a seminal sociolinguistic work mainly based on the idea of a (cultural) linguistic continuum.

Another consideration is needed: non-terminal symbols have been postulated, by definition, in rewriting rules (or recently, merging operations) and their graphical representations upheld since the beginning of generative grammar: the combination of constituents is represented as a *node* (vertex) distinct from them, considering again (5-16b).

In that example, X and Y are inputs to merger (or the right-hand part of a rewriting rule). Merging X and Y has been assumed to result in a new syntactic object {X, {X,Y}}, where the new node is introduced along with two directed edges connecting it with the inputs.

Chomsky (1995) argues that the label of the new node can be identified with that of X or that of Y in a principled manner; still, the X we have inserted in (5-16b) is a node distinct from X and Y.

I believe that the above representation of syntactic structure is not obligatory. Alternative and simpler graphical representations would be possible (and I have tried to demonstrate it in Chapter 3). Merging X and Y could be graphically represented just by drawing a directed edge (*barely*, an oriented *line*) from one of them toward the other.

The main suggestion for a possible theory is that the graphical representation adopted in Chapter 3 allows only lexical (not functional) items as its vertexes[102].

In the present graph theory each lexical item has to be related to some other lexical items (a straight locality, again in the sense of Collins, 1997). Then, a set of operations has to be found.

Obviously, assuming that language is a biological faculty, its operations need to *maximize resources* (cf. Chapter 1). A parallel could be found in the cell metabolism, with the citric acid cycle, also known as the tricarboxylic acid cycle (henceforth: TCA) or the Krebs cycle, (or rarely, the Szent-Györgyi-Krebs cycle) which is a series of enzyme-catalysed chemical reactions of central importance in all living cells that use oxygen as part of cellular respiration.

TCA is a very productive process. In aerobic organisms, the TCA is part of a metabolic pathway involved in the chemical conversion of carbohydrates, fats and proteins into carbon dioxide and water to generate a form of usable energy. The point is: if lexical items were totally dissociated, they would never be selected in syntactic derivation, so the energy would be wasted.

The relations among items might involve selection and a form not too specialized of sub-categorization as possible devices. In this way, it is reasonable to represent each lexical item as a vertex of a graph and its selectional paths with (for) other lexical items in terms of mutually adjacent *directed* edges (forming a cluster of this kind: *v,e,v′*). Features or function-items, as electrons all around the atom, mark the relations between lexical vertexes. In these terms, following a rudimentary "linguistic chemistry" the strength or the frailty of a linguistic bond may be interpreted by the richness *vs*. poverty of the edge-features.

[102] A structural question may arise: how such a graphical representation is obtained? It might be formed by introducing lexical items one by one from the lexicon as Frampton & Guttman (1999) claim (and as I also suppose cf. Chapter 3), or the Lexicon itself could be seen as a (big) graph with lexical items as its vertexes and their selectional relations (expressed by functional features as its edges), which is plausible, so that the graphical representation of a syntactic structure can be regarded as a *subgraph* of the lexicon... Other options are welcome.

Here is the model of the possible minimal syntactic unit (the basic "bond") in linguistics, following a conceivable theoretical implication of the new representation developed in this work:

(5-17)

$$\underset{\textit{lexical item}}{v} \; \overset{\{\textit{set of features/fuctional items}\}}{\overline{\qquad\qquad e \rightarrow \qquad\qquad}} \; (v')$$

In the minimal *(v,e)* structure represented in (5-17), *v* stands for a lexical item and *e* stands for a set of features/functional items that drive the linking/selectional path toward the vertex *v'*. Thus, edges are the very dynamical components of the Lexicon.

The linguistic output, if we pursue a recursive structure of this sort, is necessarily a basic *tree*, following this formal definition, adapted from Diestel (2005):

In graph theory, a tree is a graph in which any two vertices are connected by exactly one path, where a path is a sequence of vertexes such that from each of its vertices there is an edge to the next vertex in the sequence.

Edges, anyway, are somewhat problematic. We have assumed that a single edge could represent a morpho-syntactical *set* of features/items, but the assumption I made: *"One vertex one edge"* could be easily shifted, reaching this proposition: *"One vertex, many edges"*(see the multigraphs of Paragraph 2.2.3). Take a simple Italian word: ragazz-e (*girls*). The single morpheme /e/ encode (at least) two different features {+plural; +feminine}. One could presuppose, for this linguistic item, the necessity of two different *relational* paths. Well, I think I need to formulate a principle:

ADDITIVITY PROPERTY OF EDGES

The Additivity property of Edges states as follows:

Given e as an edge and (α,β,x) *as a set of features:*
$e(\alpha + \beta + \ldots x) = e(\alpha) + e(\beta) + \ldots e(x)$.

This proposition says that *e* manifests a sort of group *homomorphism* with respect to a *featural* addition. A strict parallel with linear functions is evident. Given the fact that an edge has by definition a linear nature, we may argue that in a *linear system*, the following "physiological" (and *corollary*) principle raises:

The linked response at a given place and time caused by two or more independent stimuli is the sum of the responses which would have been caused by each stimulus individually.

Thus, that is the reason we assume a single edge as the habitat of (potentially) many linguistic functions.

An adjacent principle, by representational constraints, emerges:

VERTEXES *MINUS* ONE PRINCIPLE

A syntactic graph has the same number of edges than vertexes plus one.
So (e = v-1).

If an edge is removed, the graph ceases to be connected (thus, a natural language would not be possible), as we have seen in Chapter 2. If more that one edge between two vertexes is provided, a *cycle* would be created.

In the following part of this paragraph, I try to suggest some essential, representational principles for the growth of the theory.

PRINCIPLE OF ASYMMETRY / ORIENTATION OF SYNTACTIC GRAPHS[103]

A directed Graph (D) is an orientation of an undirected graph (G) if V(D)= V(G) and E(D) = E(G) and if {init(e), ter(e)[104])} = {x,y} for every edge x=xy.

Crucially, an oriented, asymmetrical graph is a directed graph without loops or multiple edges. Otherwise a graph would be symmetrical (see the paragraph 5.3.). This is the case where each pair of vertex linked in one direction is also linked in the other. This *palindromic* two-faced Janus may happen in languages only as an accident, as the Italian example *"Anna ama*

[103] Remember again from Chapter 3 that Syntactic graphs have been considered to be *directed graphs*.

[104] Commonly in Graph theory, an edge is said to be directed from init(e) to ter(e). Note also that if init(e)= ter(e), edges become loops (Cf. Diestel, 2005).

Anna" (Annie loves Annie). Another question is, at this point: how many features are conceivable along an edge? I propose the following principle:

THE EDGE SATURATION PRINCIPLE[105]

All syntactic operations must be limited to a fixed range between a minimum and maximum value. If the result of an operation is greater than the maximum[106], it is set to the maximum, while if it is below the minimum it is set to the minimum. Value becomes "saturated" once it reaches the extreme values; further additions to a maximum or subtractions from a minimum will not change the result.

Incidentally, this principle could account why some linguistic operators (functional items) are presupposed at PF.

Consider now the way a syntactic graph could develop:

BASIC SYNTACTIC GRAPH GROWING ALGORITHM

Input: A graph G and a starting vertex $v \in V_G$

Output: A spanning basic tree X of the component $C_G(v)$ *and a standard vertex enumeration of* $C_G(v)$

Initialize: X as vertex v.

Write: 0 on vertex v

Initialize: a counter i: = 1

While X does not yet span component $C_G(v)$

Choose: a frontier edge (e) for X

Let the vertex w be the endpoint of e

Add: e and w to X

Write: i on vertex w

Record: X and vertex enumeration of $C_G(v)$

[105] Notice that a saturation principle enables efficient algorithms for many problems, particularly in digital signal processing (a field I have investigated during my work at Tempo Reale, Firenze; cf. www.centrotemporeale.it). For example, adjusting the volume level of a sound signal can result in overflow, and saturation causes significantly less distortion to the sound than wrap-around. In the words of researchers G. A. Constantinides et al (2003):

"When adding two numbers using two's complement representation, overflow results in a 'wrap-around' phenomenon. The result can be a catastrophic loss in signal-to-noise ratio in a DSP system. Signals in DSP designs are therefore usually either scaled appropriately to avoid overflow for all but the most extreme input vectors, or produced using saturation arithmetic components (cf. Constantinides G. A. et al.2003. "Synthesis of saturation arithmetic architectures" in ACM Transactions on Design Automation of Electronic Systems, 8 :3.).

[106] Traducing this consideration in minimalist terms we may say that this set the uninterpretable ϕ-features of a predicate to *a maximum*.

Note that what we call *vertex enumeration* is a one-to-one assignment of the integers *0,1,…,n-1*to the vertexes of a graph.

This is an algorithm *standardly* assumed in Graph Theory (cf. Diestel, 2005 among others) for structures as the one I have in mind here.

I give now a revised version of the *growing graph algorithm*, based on the necessity of a syntactic object to be a *connected* graph (cf. Chapter 2 and 3), and the possibility of an edge to be prioritized,

Alias

EDGE PRIORITIZED-PRINCIPLE

Input: A connected graph G and a starting vertex $v \in V_G$
Need: a rule for prioritizing frontier edge(s)
Output: A spanning tree X and a standard vertex enumeration of V_G
Initialize: X as vertex v.
Initialize: the set of frontier edges for X as empty
Write: 0 on vertex v
Initialize: a counter i: = 1
    While X does not yet span G
Update: the set of frontier edges for X
    Let: e be the designed frontier edges for X
    Let: w be an unlabeled endpoint of e
Add: e and w to X
Write: i on vertex w
Record: X and its vertex enumeration.

ENUMERATION PRINCIPLE

Given n labelled lexical vertexes, there are n^{n-2} *different ways to connect them to make a syntactic graph.*

This principle shares the same ground of the so-called *Cayley's formula* (Cf. Diestel, 2005) in topological graph theory. It is a necessary fact, given our hypothetic *representation* of human syntax.

DIRECTIONALITY PRINCIPLE (*alias* ROOT PRINCIPLE)

A graph is called a rooted graph (tree) if one vertex has been designated the root, in *which case the edges have a natural orientation, towards or away from the root.*

This principle has some similarities with the Locus Principle of Chris Collins (2002) and assume that a syntactic derivation must start from a (*very first*) lexical item.

PATH'S UNIQUENESS PRINCIPLE

Premise:

Given the topmost (first) vertex in a graph (tree) called the root vertex, this root vertex will not have parents (it has a lonely adjacent edge).

Being this vertex the vertex at which operations on the syntactic graph commonly begin (although we have to say that in Graph Theory there exist some algorithms that begin with a leaf nodes and work up ending at the root and in some trees, such as heaps[107]*, the root node has special properties: every node in a tree can be seen as the root node of the sub-tree rooted at that node), thus all other vertexes can be reached from it by following edges. In our formal definition, each such path is unique.*

Finally, a (strictly) topological principle is needed and must be assumed as an axiom by the present hypothesis. It is the most important *lexical* principle, and I propose it, updating again the *Loci principles* of Collins (2002) and Bowers (2001[108]). It is a principle that join together the relational operation *Selection & sub-categorization* assumed by Bowers (2001; Cf. paragraph 3.8):

THE TOPOLOGICAL PRINCIPLE

Given that the syntactic information specifies the syntactic environment in which it occurs:

A lexical item (a vertex) can only occur in a syntactic environment which matches its selection/sub-categorization frames.

[107] A heap is a specialized tree-based data structure that satisfies the heap property: if B is a child node of A, then key(A) ≥ key(B). This implies that an element with the greatest key is always in the root node, and so such a heap is sometimes called a max heap. (Alternatively, if the comparison is reversed, the smallest element is always in the root node, which results in a min heap.) This is why heaps are used to implement priority queues. The efficiency of heap operations is crucial in several graph algorithms (cf. Gross and Yellen, 2004).

[108] Remember from Chapter 3 that Bowers' proposal follows chronologically the original Collins idea.

Following Bowers and Collins a corollary emerges:

THE VERTEX SATURATION PRINCIPLE

All the sub-categorization conditions and selectional requirements of a vertex (a lexical item) must be satisfied before a new vertex may be taken from the Lexicon, again given that the syntactic information is sensible to its environment[109].

5.2.2 Again on the *edgeness* of Case. A strong empirical evidence: Bidirectional Case Markers in West African Languages (Heath, 2006).

My proposal, although somewhat bizarre and anti-dogmatic (see below for even more *retro-viral* accounts), is strengthened by an empirical fact recently discussed by Heath (2006), in a work appeared in Natural Language and Linguistic Theory: *Bidirectional case markers in West African languages*.

In the Songhay language family[110] studied by Heath, there are specifically targeted morphemes inserted between subject and object NPs that would otherwise be adjacent. They therefore specify both that the NP to the left is a subject, and that the NP to the right is an object, and they cannot be "bracketed" uniquely with either. This is shown by the fact that these morphemes are absent when either subject or object position is (structurally and phonologically) absent. The operation inserting such morphemes must have reference to linear (*graphical*) adjacency.

In (5-18) is represented the word order of Songhay languages

(5-18) *Major constituent orders (X=everything else)* (Heat, 2006: 89)
S-infl-V-X; S-infl-O-V-X

For convenience one could refer to S-infl-V-X as SVO; to S-infl-O-V-X as SOV.

The languages from the Songhay family that are *crucial* for the present discussion are Koyra Chiini, spoken around Timbuktu, Koyraboro Senni around Gao, and Tondi Songway Kiini in the village of Kikara (cf. Heat,

[109] In some ways, I assume that a linguistic context has to been responsible for triggering the selectional / subcategorizational properties of a lexical item.

[110] The Songhay languages are a family of languages spoken chiefly in northern Mali, in the eastern part of the Republic of Niger, and in pockets in several adjacent countries (cf. Heat, 2006 also for interesting phonological considerations).

2006).

Here is an example of sentences from Koyra Chiini:

(5-19) [yer alhawa di kul] tin-ey di (Heat, 2006: 91)
[1Pl passion Def all] weight Def
'the weight (=focus) of all our desire'

The bracketed compound-initial phrase is a complete NP including its own possessor, definiteness marking, and universal quantifier. The compound-final noun, or rather the entire compound treated as a noun, then gets its own definiteness and/or plural marking as appropriate. This is a sort of loose compound sequence [[NP] N] (cf. Heat, 2006).

Thus, because loose compounds like (5-19) are permitted in all of these languages, where a basic SOV word order occurs a sentence beginning for example like [the man the dog. . .] could initially be mis-parsed as a loose compound ("the man's dog"). The correct parsing would require a sort of retroactive re-computation after the listener identifies the verb as transitive. Anyway, this identification could be itself tricky, since many transitive verbs can also be used intransitively (with unergative or unaccusative interpretations).

Heat (2006) notes that the Songhay languages do not need to worry about this parsing problem. This is because they insert, between otherwise adjacent subject and object NPs, a morpheme /*na*/. I give here two examples. The first is (5-20a) for Tondi Songway Kiini and the second (5-20b) is for Koyraboro Senni. Another example for Koyraboro Senni is given here in (5-21) to show that using a pronominal clitic instead of a full NP for subject and/or object does not block the insertion of the morpheme /na/. 'Hit' in the free glosses of Heat (2006) is in English past tense (Songhay perfective).

(5-20)

a. hàr-òó nà háns-òò kárú (Heat, 2006: 92)
man-DefSg $_{\text{Case-marker}}$ dog-DefSg hit
"The man hit the dog."

b. har-oo na hãyš-oo kar
man-DefSg $_{\text{Case-marker}}$ dog-DefSg hit
"The man hit the dog."

(5-21) ay na i kar

1SgS Case-marker 3PlO hit
"I hit them."

The field-work of Heat (2006) is interesting because, with a relevant set of examples, the author is able to rule out other possible interpretations for that morpheme, as an ergative nature (implying /na/ bracketed with the subject), an accusative nature (implying /na/ bracketed with the object) or the possibility of considering /na/ as an inflectional morpheme.

These data increase the evidence that complex case-marking operations can apply in a *centrally* located morphology component (definitely, an *edge*) that has access to linear (probably, instead of categorial) relations. This phenomenon could also suggest in relation to the architectural basis of Minimalism that "morphology", construed as the *zone* (again a topological *shift*) where categorial structure and (linear) form are both *accessible* to grammatical rules, can carry out many operations previously assigned to a (pre)spell-out syntax.

Finally a (graphic) self-evidence revealed by Songhay languages:

A vertex cannot be adjacent to (linked with) another vertex.

5.2.3 A note on the weakness of Burzio's Generalization (and far beyond)

The above cited (cf. paragraph 5.2.1) Burzio's Generalization faces several cross-linguistic problems. I point out the problems of that generalization here, for the importance that it has for the syntactic notion of *position*. A notion that cannot be maintained in our graph based account. Also, the crucial notion of theta-role has to be tested with accuracy, in the domain of a graph theoretic syntactic account. Probably theta-roles could be assumed as a set of syntactic oriented features adjacent to a verb, but I do not want to act systematically like a *minesweeper* and I will not investigate further this issue.

Resuming the issue, Burzio (1986) elegantly asked why, if verbs assign accusative Case to their objects, a NP that remains inside the VP in an unaccusative construction cannot have accusative Case. See the following example from the seminal article of Belletti (1988):

(5-22) All'improvviso è entrato un uomo dalla finestra.
Suddenly be3.sng entered a man[NOM/*ACC] from-the window
"Suddenly a man entered from the window." (Belletti 1988:17))

Considering that unaccusative verbs[111] lack an external (agent) theta role, Burzio links the ability of a verb to assign accusative Case to its ability to assign an external (agent) theta role.

Here is Burzio's Generalization:

All and only the verbs that can assign a θ-role to the subject can assign accusative Case to an object. [subject = external subject (agent)] (Burzio 1986:178)

Note that in the very first formulation of Burzio's Generalization, the subject or *agent* theta-role plays a crucial point. The generalization elegantly predicts that:

i) No verb without an agent subject can assign accusative Case.
ii) Any verb with an agent subject can assign accusative Case.

Anyway there are many inter-linguistic problems. Consider the construction in Russian given in (5-23) (termed "adversity impersonal" in Babby (1993), Tsedryk (2003) or as "accusative unaccusative" in Levin and Freidin 2001). It presents a counterexample to Burzio's Generalization.

(Markman 2005: 1-2)

(5-23)
a. Bumag-u sozhgl-o
Paper-acc burned-neut
"The paper got burned"

b. Dim-u udaril-o
Dima-acc hit-neut
"Dima got hit"

c. Berez-u svalil-o
Birch-acc make-fall-neut

[111] It interesting to note that other authors, such as Van Valin (1990), claim that unaccusativity is purely an aspectual distinction. In example, *resultative predicates* must be predicated of an *Undergoer* role (the argument of the *BECOME* predicate in a conceptual structure), and this role is only present in *accomplishments* and *achievements*. Unergative verbs are *aspectually* activities, which provide no slot for an *Undergoer* argument, hence their incompatibility with resultative predicates.

"The birch was caused to fall"

The NPs in (5-23) have the accusative Case, but there is no implicit agent in the construction. This is demonstrated by Markman (2005) by the fact that this kind of constructions do not allow control into purpose clauses, do not allow an agentive *by*-phrase, and also this construction is incompatible with an agent-oriented adverbial such as the item *special'no* (purposefully).

Then, consider again a challenging language: Icelandic[112]. An evident asymmetry emerge with Icelandic *quirky objects* (cf. Sigurdsson, 2002):

(5-24)
a. Klara òskadi Olaf-i alls gods
Klara wished Olaf-dat everything-gen good-gen
"Klara wished Olaf all the best"

b. Thss vas òskad
This-Gen was wished
"This was wished"

c. Henni vas òskad Thss
Her-gen was wished this-gen

Furthermore, Icelandic has another interesting property (already seen from Russian and also attested in Kannada cf. tWAoLS of Comrie *et al*. (2005), among other languages):

(5-25)
a. Eg fyllti batin-n
I filled boat-acc
"I filled the boat"

b. Batin-n fyllti
Boat-acc filled
"The boat was filled"

A Baltic language, Lithuanian has another relevant property:

[112] I thank my great friend A'ki G. Karlsson for having confirmed to me the grammaticality of the following examples.

(5-26) Ar buta tenai langin-iu? (Landau, 2003)

And be-pass there window-gen

Tentatively, "And there had been existed by windows?"

The example above seems to be "a passive of an unaccusative": a very strange phenomenon and a difficult explanation.

Then, as Mahajan (2000) among others point out, the presence of an external/agent subject is no guarantee of an accusative object, since agentive ergative subjects in many languages (such as the following example from Hindi) can occur with nominative objects:

(5-27) Raam-ne rotii khaayii thii. [Hindi]

Ram-ERG bread(fem)-NOM eat(perf,fem) be(past,fem)

"Ram had eaten bread." (Mahajan 1990: 73)

These cross-linguistical widespread constructions are definitely counterexamples to the Burzio's generalization.

Considering Case barely as *a linking device in a graph* could be more productive. In that way, we may account, in example, for *multipurpose* items as in Mapudungun (Araucanian; Chile), already cited in a previous footnote, which has only one overt case suffix -*mew/ mu* expressing diverse functions. I will return again along this chapter over the puzzle of what I call a *multipurpose syntax*.

I assume also that the labels Nominative, Dative, Genitive are *cultural products*. The natural tendency for a standardized pattern is somewhat responsible for this cultural driftage. Also assuming a possible scale of *markedness* regarding Case expression in problematic languages (Icelandic, Lithuanian, Hindi, Russian etc.), would turn out to be a cultural artefact. We may simply assume, instead, that there exist linguistic functional-orientational items that drive the syntactic derivation and that a standardized pathway is one of the best possible solutions.

Someone could consider this one as a maximalist assumption, others could consider this assumption as *foolish* reductionism. For me is a *possible path* to follow.

Note that I do non assume any functionalist necessity (any program) for the language development. I firmly believe that language is a (biological) accident (see PP&U, 2004). Communication among humans could have been pursued with other strategies and other devices (cf. also Moro, 2007).

Take as a parallel the *endosymbiotic* hypothesis for eukaryotes. It suggests that mitochondria descended from specialized bacteria[113] (probably *purple non-sulfur* bacteria) that somehow survived endocytosis by another cell, and became incorporated into the cytoplasm. The ability of symbiotic bacteria to conduct cellular respiration in host cells that had relied on glycolysis and fermentation would have provided a *considerable evolutionary advantage*. In a similar manner, host cells with symbiotic bacteria capable of photosynthesis would also have had an advantage. The incorporation of symbiotes could have increased the number of *environments* in which the cells could survive.

Thus, the endosymbiosis with mitochondria may have played a critical part in the survival advantage of eukaryotic cells (our cells), but it is *barely* a biological evolutionary accident.

Tentatively, the development of a set of functional operations in human language is our specie-specific *evolutionary advantage*.

The chimpanzees Washoe and Nim Chimpsky and the gorilla Koko were almost unable to reach any competence or production of functional items, and, more generally, were not able to go beyond item's *referential* properties.

5.3 Complementizer Deletion

A further interesting fact is that (cross-linguistically) complementizers may have a phonological content but it may be also omitted. The most studied case is perhaps English *That-deletion*. Thus, English complementizers or "sentence introducers" like *that* may be deleted in structures like (5-28).

(5-28) Anderson and Lightfoot (2003: 44)

a. It was apparent [$_{CP}$ that/e Marco had left].
b. The book[$_{CP}$ that/e Marco wrote] arrived.

[113] Mitochondria have many features in common with prokaryotes. They contain ribosomes and DNA and are formed only by the division of other mitochondria. As a result, they are believed to be originally derived from endosymbiotic prokaryotes. Studies of mitochondrial DNA, which is often circular and employs a variant genetic code, show that their ancestor, the so-called proto-mitochondrion, was a member of the Proteobacteria. In particular, the pre-mitochondrion was probably related to the *rickettsia* (cf. Karp, 2004 as a starting point). However, the exact position of the ancestor of mitochondria among the alpha-proteobacteria remains controversial. The endosymbiotic relationship of mitochondria with their host cells was popularized by the works of Lynn Margulis. Notice also, that a few groups of unicellular eukaryotes lack mitochondria: the microsporidians, metamonads, and archamoebae. hese groups appear as the most primitive eukaryotes on phylogenetic trees constructed using rRNA information, suggesting that they appeared before the origin of mitochondria. However, this is now known to be an artifact of a kind of *long-branch attraction* – they are derived groups and retain genes or organelles derived from mitochondria (e.g., mitosomes and hydrogenosomes).

c. It was certain [$_{CP}$ that/e Marco had left].

This operation does not apply in languages like French or Persian, where the complementizers *que* and *ke* are invariably present. Nonetheless, following Anderson and Lightfoot (2003: 45), the English specific operation is "learnable, because children typically hear sentences in both forms, sometimes with the complementizer present, sometimes not. Therefore an operation "Delete *that!*" meets the basic requirements for inclusion in the grammars of English speakers".

Anyway, there are context in which the complemetizer is obligatory:

(5-29) Anderson and Lightfoot (2003: 46)

a. It was apparent to us yesterday[$_{CP}$ that/*e Kay had left]
b. The book arrived [$_{CP}$ that/*e Kay wrote].
c. [$_{CP}$ that/*e Kay had left] was obvious to all of us.
d. Fay believes, but Ray doesn't, [$_{CP}$ that/*e Kay had left].

The difference between (5-28) and (5-29) is assumed to be, by Anderson and Lightfoot, that in (5-28) *that* is the top-most element in a clause (CP) which is the complement of an adjacent, *overt* word; in (5-29a,b) the embedded clause [CP *that Kay had left*] is the complement of *apparent* in (5-29a), *book* in (5-29b), nothing in (5-29c), and *believes* in (5-29d). In none of the cases represented in Anderson and Lightfoot (2003) is the CP the complement of the adjacent word in (5-29) and therefore their proposal is that "we have found a reason" for which *that* may not be deleted.

Anderson and Lightfoot propose the following criterion, that they label the *UG Condition*:

An element may be deleted if it is the top-most item in a complement of an overt, adjacent word. (Anderson and Lightfoot, 2003: 47).

It is a very interesting principle and the authors firmly believe in their statement (such that they find boring for their audience to test the UG criterion among various languages).

But, maybe their generalization is too wide. Without going too far, seeking for some exotic languages[114], consider a well studied (also for sociolinguistic

[114] I personally suggest Tagalog, if you are interested in destroying someone's generalization.

reasons) variety of English; the variety of English spoken in Northern Ireland (so-called Belfast English) manifest this evidence: *the complementizer may not be deleted (is strictly required) even if is the top-most item in a complement of an adjacent word*.

(5-30) John wonders which novel that/*e he read (Belfast English)

Also, Standard Italian (and its dialectal varieties) shows some interesting linguistic facts. See the following examples:

Standard Italian

(5-31)
a. Salomé sa che/*e cucina lo *zeresk-polo* meglio di chiunque altro.
Salomé knows that cook-3ps the *zeresk-polo* better than any other
"Salomé knows she cooks *zeresk-polo* better than anyone".

b. Salomé crede che/e possa essere un'ottima pallavolista.
Salomé believes that can-3ps be a great volley-ball player
"Salomé believes she can be a great volley-ball player"

Venetian (Northern Italy)

(5-32)
a.Non so quando che/*e la Maria telefona
not know1sg when that the Mary calls
"I do not know when Mary calls"

Standard Italian

b. Non so quando *che/e Maria telefona
Not know1sg when *that Mary calls
"I do not know when Mary calls"

These are interesting facts. Considering (5-31a,b), for example: how can we explain in Italian - without recurring to the *selectional* properties of the items *sa* (knows) vs. *crede* (believe) - given a structural principle, that minimally paired discrepancy? It would be a fantastic, ground-breaking result to find a principle that say to us definitely when an item is *obligatory* and when it *may* *optionally* be deleted, but this is not the case of Anderson and Lightfoot (2003) UG condition.

In a graph theoretic perspective, the interesting observation is (loosesly) that, as a functional linguistic item, the complementizer may be deleted. The patterns in which its deletion occurs, is somewhat difficult to be determined (cross-linguistically, as well as in a language-internal perspective).

Probably the deletion is determined by the interaction of various linguistic features (and selectional properties of the lexical items), but I will not investigate further that field in the present work. Refer to our *Egde Saturation Principle* for an *a priori* motivation.

The relevant observation remains that *the complementizers are optionally elided in finite complement clauses that are selected by a certain set of verbs*. In the generative tradition, it has been a common assumption that the elided complementizer is an *empty category* lacking phonetic realization (see, Stowell, 1981; Pesetsky, 1995; Boskovic and Lasnik, 2003), although the exact formulation of this assumption varies broadly from one proposal to another[115]. Anyway, in a radically different proposal, Boskovic (1997) has advanced another kind of analysis, based on strict minimalist assumptions, which holds that no complementizer (*no projection*) exists in a complementizer-less embedded clause[116]. Obviously, if Boskovic (1997) is right our graph inspired proposal in which the complementizer is *on the edge between two (lexical) vertexes* would be immediately ruled out.

An empirical observation that Kishimoto (2006) has made in a recent LI's *squib* seems to resolve the present issue. I describe the facts below. Kishimoto, looking at the behavior of adverbial particles in Japanese, especially drawing on data from a western dialect of Japanese - the Kansai dialect - suggests, contrary to Boskovic (1997), that a null complementizer (in a graph oriented perspective, an *empty* edge) *must* exist as a syntactic object in a complementizer-less embedded clause, even if it is not phonetically realized[117]. As reported by Kishimoto in his work, in the Kansai dialect,

[115] Pesetsky (1995) argues that the restricted syntactic distribution of null complementizers derives from the need to raise a null complementizer serving as an affix to a higher position. In contrast, Boskovic and Lasnik (2003) argue that it derives from a PF affixal property, which is licensed by way of morphological merger, providing an account of the distribution of null C in English that does not appeal to the notion of government.

[116] Boskovic (1997) economically claims that a complementizer is literally missing in a declarative embedded clause such as *John thinks Mary ate*, since its presence is neither motivated semantically nor required lexically.

[117] Notice that Standard Japanese (like French and Persian) does not allow complementizers to be omitted in subordinate clauses.

complementizer deletion take place in finite complement clauses selected by a certain class of verbs such as *yuu* (to say) and *omou* (to think)[118]. See the example below:

(5-33)
John-wa [Mary-ga ki-ta (tte)] yuu-ta/omoo-ta.
John-TOP Mary-NOM come-PAST that say-PAST/think-PAST
"John said/thought (that) Mary came." (Kishimoto, 2006: 341)

These fact suggest that complementizer deletion takes place in the Kansai dialect in the same way as *that*-deletion in English. Thus, in the Kansai dialect a complementizer can be phonologically null when construed as being located in the (base-generated) complement positions of verbs like *yuu* and *omou*.

Now, the most interesting thing is to analyze the behavior of adverbial particles such as *sura* 'even', *sae* 'even', and *dake* 'only', that in the Kansai dialect can attach to the complementizer *-tte*.

(5-34) John-wa [Mary-ga koko-ni ki-ta tte-*sura*] iw-ankat-ta.
(Kishimoto, 2006: 343)
John-TOP Mary-NOM here come-PAST that-even say-NEG-PAST
"John did not even say that Mary came here."

In Japanese, an adverbial particle is a *dependent* element attached to a lexical item, and it can be assumed to be head-adjoined to its host (Kishimoto, 2006).

It is interesting to see the following constraint: a particle can stand to the right of a lexical head (e.g., *hon-sura* 'book-even'), but it cannot stand to the left (e.g., **sura-hon* 'even-book') or inside a complex lexical head (e.g., **e-sura-hon* 'picture-even-book'). This small cluster of adverbs is assumed to include functional items and its behavior is consistent with a graph theoretic account. As I have already pointed out, while a lexical item with a referential (or

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[118] Kishimoto (2006: 342) notes also that, as in English, in the Kansai dialect, when a complement clause is dislocated from its original position, the deletion of the complementizer is blocked (see also Saito, 1985).

(i) a. [*(That) Mary was honest]$_i$ John thought t_i.
This is also true for the Kansai dialect of Japanese
b. [Mary-ga ki-ta *(tte)]$_i$ John-ga t_i yuu-ta.
Mary-NOM come-PAST that John-NOM say-PAST
"*(That) Mary came John said."

eventive) nature has a fixed position in a vertex position (so, no other item can occupy those vertex), a set of functional items can *share* the same edge.

The example in (5-34), therefore, states that the particle is associated with the complementizer. In a case like (5-34), it is also possible to elide the complementizer while retaining the adverbial particle, as shown in (5-35), taken again from Kishimoto (2006).

(5-35) John-wa [Mary-ga koko-ni ki-ta *sura*] iw-ankat-ta.
John-TOP Mary-NOM here come-PAST even say-NEG-PAST
'John did not even say that Mary came here.'

Notice that if the complement clause with *sura* in (5-35) is scrambled to the front, the sentence becomes unacceptable.

Since an adverbial particle can be interpreted in the same way in a complementizerless clause as it is when associated with a complementizer, we can conclude that a complementizer-less clause like (5-35) has an invisible complementizer habitat, hosting an adverbial particle, and consequently that it must have a linking-edge with a null complementizer or, in the traditional representation, a CP projection even when the complementizer is not phonetically realized (*pace* Boskovic, 1997).

Another kind of explanation for the phenomenon of complementizer deletion is given by Pesetsky (1998) in an *Optimality theoretic* fashion. I share with Pesetsky's view some basic points; thus, I plan to close this paragraph reviewing his proposal.

Pesetsky (1998) starts from the consideration that there are many languages that front the finite verb to a position that can be analyzed as clause initial C. Then, in some languages, such as Irish, the fronted verb is pronounced immediately to the right of the complementizer, without intervening adverbs or other material[119].

(5-36) *Irish* (Pesetsky, 1998: 2)
Duirt Seàn [$_{CP}$ go bhfuil Chatal ag-rince]
Said John that is Charles –ing dance
"John said that Charles is dancing".

In other languages with "V-to-C" the complementizer is unpronounced. This is, for example, the pattern in German embedded clauses, as first noted

[119] Anyway, note that, in an influential paper, McCloskey (1992) argues that Irish lowers C to I rather than raising inflected V to C.

in Den Besten (1983). Den Besten argued that German V2 is a *substitution* of the verb into C. Den Besten noted a complementary distribution of fronted verb and pronounced complementizer:

(5-37) *German* (Pesetsky, 1998: 2, taken from Den Besten 1983)
a. Hans sagte dass er glücklich ist
Hans said that he happy is
"Hans said he is happy"

b. Hans sagte er sei glücklich
Hans said he is happy
"Hans said he is happy"

Pesetsky (1998) made an interesting observation, arguing that there is a sort of *gap* in the paradigm: there are no languages in which the complementizer is pronounced to the right of a fronted verb, as in an hypothetic pseudo-Irish or pseudo-German. Again, this empirical observation is coherent with the prediction of a Vertex-*first* hypothesis in a syntactic graph theory.

(5-38) *Pseudo-Irish* (Pesetsky, 1998: 3)
#Duirt Seàn [$_{CP}$ bhfuil go Chatal ag-rince]
Said John is that Charles –ing dance
"John said that Charles is dancing".

Pesetsky noted that this gap is reminiscent of the doubly filled Comp filter of Keyser (1975) and Chomsky and Lasnik (1977), except that is crucially sensitive to the *linear order* of complementizer and verb.

It is possible to ask: is left adjunction to C (im)possible? Or does it intervene a mechanism of *induced* deletion when the verb is left adjoined to C (so, the complementizer is not pronounced)?

Trying to answer these questions, Pesetsky (1998: 5) made the following generalization:

(5-39) If the complementizer heading CP cannot be pronounced at the left edge of CP, it is unpronounced.

This generalization follows the empirical facts implied by the linguistic universal expressed below:

(5-40) *Verb adjunction universal*

$[_{CP}$ comp verb] *vs.* $*[_{CP}$ verb comp] (Pesetsky, 1998: 18)

A graph representation keeps immediately the linguistic universal shown in (5-40). A vertex could not be adjacent to another vertex (indeed, a matrix verb cannot be adjacent to a selected (*embedded*) verb, moving to the left of a pronounced complementizer).

Pesetsky discusses data from French and English to justify his generalization and, analyzing various patterns, such as infinitival relatives, French relatives with pied-piping of PP etc., he arrives at the following principle:

(5-41) DELETION OF CP (Pesetsky, 1998: 21):

The head or specifier of a CP may be deleted only if that CP is a complement.

The principle above attracts the same critics showed here for Lightfoot and Andreson *Delete that!* Principle. There are multi-level filters that cross-linguistically or in a language-internal perspective seems to show that it is (far) more reasonable to consider the selectional properties (features) of a given (lexical) item (such as matrix verbs) as a trigger for the phonological deletion of another (functional) item (such as complementizers).

Anyway there are two considerations in Pesetsky's work that are interesting from a graph theoretic perspective and I manage to conclude this paragraph considering them. First, he assumes as an optimal syntactic principle the so-called Telegraphic principle (TEL):

TEL: *do not pronounce function word*. (Pesetsky, 1998: 16)

Pesetsky argues that an "optimal" syntax is "syntax without functional items". TEL could be expressed in our graph model in this way: *at the most economical level all edges may be presupposed.*

Personally, I don't think that is possible to find a natural language without functional words, due to (inevitable) semantic-pragmatic constraints. Even Gil (2001), who claims to have found an (isolating) mono-categorial language in an Indonesian town (but maybe a sort of *lingua franca* / *pidgin* developed for commercial purposes), has to admit the existence of a (small) subset of function–words. I think that nothing that is (strictly) syntactic could determine (predict) the presence vs. absent of a functional item, especially the *positional* constraints/principle of Lightfoot & Anderson and Pesetsky.

The second principle, which is essential in a syntactic graph theory, and, again, is shared with a basic assumption in Pesetsky's work, is the principle of Recoverability.

RECOVERABILITY: *a syntactic unit with semantic content must be pronounced unless it has a sufficient local antecedent.* (Pesetsky, 1998: 15).

It is interesting to notice that functional items do not have a semantic *weight*, just because they are syntactic operators; thus the principle of Recoverability does not regard them. As already said extensively, the assumption of a strict syntactic locality is essential for the development of a Graph model. A model that does not imply traces or copies, anyway, could seems to contradict the principle of Recoverability, but I believe anyway that it fits perfectly for syntactic graphs. An example of (very local) mechanism of syntactic retrieval is the Songhay bi-directional case marker discussed in the paragraph above. I propose (as a principle leading the communication between syntax and semantics) an updated version of the recoverability principle here:

RECOVERABILITY (UPDATED): *A lexical item must be pronounced unless it has a sufficient local antecedent. A functional item could act like a resumptive item, to preserve a local interpretability.*

5.4 Evidences from Language acquisition

Another basis for the assumption of the different status of functional vs. lexical elements in Syntax comes out from Language Acquisition. Guasti (2003) argues that all functional elements, are usually absent in children's early clauses, with the result that "children's speech strongly resembles telegraphic speech" (see Bloom, 1970; Brown, 1973 cited in Guasti, 2003).

Some typical sentences are shown in (5-42), where an auxiliary (either the perfective have or the progressive be) is lacking (indicated in square brackets) and only the participle form of the verb is expressed.

(5-42) (Guasti, 2003: 106)

a. Eve gone [has]. (Eve, 1;6)

b. Eve cracking nut [is]. (Eve, 1;7)
c. Mike gone [has]. (Sarah, 2;3)
d. Kitty hiding [is]. (Sarah, 2;10)

In children's earliest multiword utterances, modals and the copula be are also frequently absent, as (5-34a,b) illustrate.

Guasti (2003: 106)
(5-43)
a. That my briefcase [is]. (Eve, 1;9)
b. You nice [are]. (Sarah, 2;7)

Similarly, the dummy auxiliary *do* is missing from negative sentences (5-44a,b) and questions (c)

Guasti (2003: 106-107)
(5-44)
a. Fraser not see him. (Eve, 2;0)
b. He no bite ya. (Sarah, 3;0)
c. Where ball go? (Adam, 2;3)

Also, It has long been noted that from their first word combination up to about 3 years English-speaking children often produce sentences like (5-45a-d) in which either the third person singular inflection -*s* or the past tense marker -ed is missing and the verb surfaces as a bare or uninflected form:

Guasti (2003: 105)
(5-45)
a. Papa have it. (Eve, 1;6)
b. Cromer wear glasses. (Eve, 2;0)
c. Marie go. (Sarah, 2;3)
d. Mumma ride horsie. (Sarah, 2;6)

Because children rarely use functional elements[120], Radford (1990) has proposed that early clauses lack the corresponding inflectional category IP. Their representation includes only the lexical category VP.

[120] In particular all the examples taken from Guasti (2003) that I have listed here share a common property: they all express the feature content of the I node.

The hypothesis that children's clauses are VPs is also called the small clause hypothesis, a label that emphasizes the similarity between early clauses and some adult structures that have also been viewed as lexical projections of the predicate[121] (cf. Manzini, 1992 and Moro, 1997 among others).

This hypothesis is quite fascinating, even if there are some cross-linguistical facts that show its weakness (cf. Guasti, 2003 for a critical survey).

The relevant fact here, anyway, is the following: *it is evident that functional syntactical elements develop more slowly because they are more difficult to be encoded.*

5.5 Multi-relational agreement: Lakhota and Basque

Another interesting fact, regarding syntactic functional features/items could be found in those (many) languages that show, as a coding property, a multi-relational agreement. This linguistic fact is relevant for the present theory.

Take Lakhota, as an example. Lakhota is the largest of the three languages of the Sioux, of the Siouan family and represents one of the largest Native American language speech communities left in the United States, with approximately 8,000–9,000 speakers living mostly in northern plains states of North and South Dakota.

In Lakhota, transitive verbs agree with both subject and direct object. (The verb *naxïú* 'hear' takes its subject and object markers as infixes.).

Lakhota

(5-46)

a. (Miyé) mathó ki henáwíchawa...

(1sg) bear the those stem-3plobj-1sgsubj-hear

'I heard those bears.'

b. Mathó ki hená (miyé) na-má-Ø- xïú -pi.

bear the those (1sg) stem-1sgobj-3subj-hear-pl

'Those bears heard me.'

The independent pronoun *miyé* 'I' is optional and would only be used for

[121] An example of a small clause is the verbal complement following a verb of perception like *I saw John eat an orange*. (Cf. Guasti, 2003)

emphasis. Interestingly the verb shows agreement for both of its terms, and accordingly in languages like Lakhota being the *trigger* for verb agreement is not a unique property of subjects. There are even languages in which there is agreement with all three terms in a sentence with a di-transitive verb; the following examples are from Basque (Laka 1990: 15).

Basque

(5-47)
a. Ni-k hi-ri liburu-Ø bat oparitu d-i-a-t.
1sg-erg 2sg-dat book-abs one give.as.gift 3sgdobj-have-2sgiobj-1sgsubj
'I have given you a book (as a present).'

b. Hi-k ni-ri liburu-Ø bat oparitu d-i-da-k.
2sg-erg 1sg-dat book-abs one give.as.gift 3sgdobj-have-1sgiobj-2sgsubj
'You have given me a book (as a present).'

The agreement morphemes occur on the auxiliary verb *ukan* 'have' (which appears as *-i-* in these two examples), and all three terms are expressed there. Thus while triggering verb agreement is obviously a property of terms, it is not a unique property of subjects in many languages. The fact is relevant for out hypothesis because it would be difficult to explain the privileged status of the *edge* between Subject and the Verb, allowing this edge to carry features not allowed in other contexts (edges). The most one can say is that if a language has verb agreement with only one term, the default trigger is (almost certainly) the subject (cf. Van Valin (2003)).

As a trivial evidence I give the following minimal pair:

(5-48)
a. The girl knows/*know the answers.
b. The girls know/*knows the answer.

5.6 A syntactic puzzle: multipurpose sentences in Diyari

I consider the existence of languages that allow for *multipurpose clauses* as a(nother) manifestation of the *Additivity property of Edges*, revealing that an edge can potentially carry many type of functions. A pragmatic interaction is sometimes needed to avoid the potential ambiguity of syntax (see again sentences like: *I saw the man with the binoculars*).

I take an *exotic* language as the ground for the purpose of this paragraph. In Diyari (Pama-Nyungan;South Australia), clauses like those in the example (5-49) could be interpreted in the vein of a (tentative) relativization strategy, but can have several other functions apart from the function of relativization. Diyari has no specific subordination construction whose sole, or even prototypical, function is to encode a relative clause (cf. Comrie and Kuteva, 2005).

Diyari uses, instead, a general, unified modifying construction which — depending on context — may be interpreted as either a subordinate temporal, conditional or relative clause, as in (5-49).

Diyari

(5-49) (Austin 1981: 209)

tanali nina wala yanka-na talara mada kuda-na yari-yi wala-ni

3pl.erg 3sg.m.acc nest-abs make-rel.ss rain stone-abs put-pcl go.down-pres nest-loc

"If/when/after they make/made the nest, they put the rain stone in it."

The set of possible interpretation is:

a. '*Having made the nest, they put the rain stone in it.*'
b. *'They who make/made the nest put the rain stone in it.'*
c. *'They put the rain stone in the nest they make/made.'*

Incredibly puzzling. Furthermore, Diyari is interesting, also, for a relevant Case agreement phenomenon that seems to show that unmarked Case nominals *actually* bear syntactic Case features[122]. Let's see two constructions discussed by Goddard (1982) for Diyari.

One such construction concerns the expression of inalienable possession. In Diyari, the *possessor* and *possessee* are marked with the same Case, (plausibly through some *percolation* mechanism). Consider the following examples (from Goddard (1982)).

(5-50)

a. nulu [nana mara] nanda-na.

[122] Phenomena of this kind form the heart of Goddard's (1982) argument for an ergative/accusative analysis of unmarked Case nominals. Cf. also Falk (2002).

3sgERG.NFEM 1sgACC hand.ABS hit-PART
'He hit my hand.'

b. [yini milki] tanma- yi-la.
2sgNOM eye.ABS be.open- PRES-FOC
'Your eyes are open now.'

As Goddard observed, the "absolutive" head nouns cannot have the same Case features, because in one case the agreeing form is accusative and in the other it is nominative. Another example can be taken from determiners set (identical to third person pronouns) (Goddard (1982)).

(5-51)
a. [nawu kana] wapa- yi.
3sgNOM.NFEM person.ABS go-PRES
'The man is going.'

b. nulu pulana [nina putu] yi ki-na wara-y
3sgERG.NFEM 3duACC 3sgACC.NFEM thing.ABS give-PART i.AUX-PRES
'He gave them that thing.'

Constructions of this kind represent a very puzzling fact. It is clear that a syntactic analysis of Case agreement is much more complex, and less natural, if we do not assume, for instance, that superficially Caseless nominals can be formally Case marked. With the *presupposition* of the edge-items at PF, we may account for these phenomena in this way:

A Feature based model contains no (spatial) information about features within a lexical object (vertex)[123].

[123] An interesting recent position is the one of Ouhalla (2005), who demonstrated with examples mainly taken from Berber (in a paper appeared in Natural Language and Linguistic Theory) that there are empirical reasons to think that the role traditionally assigned to specialized categorial features is performed by *independently* needed features, some of which are agreement features. In appropriate contexts, for Ouhalla (2005) the verbal feature reduces to [PERSON] and the nominal feature to [CLASS]. This view, along with the fact that agreement features come in bundles, leads to a novel way of looking at verb–subject agreement. For Ouhalla as the reflex of feature-matching and deletion, verb–subject agreement is essentially a mechanism of categorization by computation and it leads to deletion of the nominal agreement feature from the verb and related functional heads and the verbal agreement feature from the subject.

In other words, features are syntactically enconded independently as operators.

5.7 Relativized Minimality and Graph Theory

Rizzi's (1990) Relativized Minimality (RM) has become a milestone of contemporary syntactic theory. RM (probably) has been triggered by considerations above the Head Movement Constraint[124] (HMC). Examples below illustrate that adjunct-extraction out of *wh-islands*, *super-raising* and *violations of HMC* have a *core* shared denominator.

(5-43) a. *How do you wonder why John fixed the car?
b.* *How$_i$ do you wonder* [CP ^{why} [IP $^{John\ fixed\ the\ car}$ $^{t}{}_{i}$]]?

(5-44) a. *John seems it is likely to solve the problem
b. * *John seems$_i$* [IP $^{it\ is\ likely}$ [IP $^{t}{}_{i}$ $^{to\ solve\ the\ problem}$]]?

(5-45) a. *How tall be John will?
b. * [CP $^{How\ tall}$ [C′ $^{be}{}_{i}$ [IP ^{John} [I′ ^{will} [VP $^{t}{}_{i}$]]]]?

The examples above have one constituent in common and that is having the antecedent (the moved category) intervenes between the antecedent and its trace. The interfering elements intrude the relation between an antecedent and its trace proposing *Minimality effect*. The interventions are the following:

i) The wh-phrase *when* in (5-43) interferes between the moved adjunct wh-phrase *how* and its trace in the embedded clause.

ii) The DP *it* in the Spec-IP of the first embedded clause in (5-44) intervenes between the moved DP *John* in the root clause and its trace in the second embedded clause.

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[124] The head movement constraint of Chomsky (1986) says:
"Movement of an X^0 category A is restricted to the position of a head B that governs the maximal projection of A".

iii) The X^0 *will* (I) in (5-45) interferes between the moved X^0 *be* and its trace under V.

However, the above examples show that the antecedent fail to antecedent govern its trace because an element of the *same* type as the antecedent interfere between the two of them and become eligible as a closer antecedent-governor of the trace. The case below shows a similar but *fundamental* case:

(5-46) a. How did you think (that) John fixed the car?
b. *How$_i$ did* [IP $^{\textit{you think}}$ [CP $^{\textit{(that)}}$ [IP $^{\textit{John fixed the car } t_i}$]]]?

(5-47) a. Will John fix the car?
b. *Will$_i$* [IP $^{\textit{John}}$ [I′ $^{t}{}_{i}$ [VP $^{\textit{fix the car}}$]]]?

Although there is an intervention of subject in the middle of wh-phrase and its trace in (5-46), the antecedent-government does not block their relationship because the two subjects are the same type of antecedent. On the same note, a subject does not block antecedent-government of an X^0 trace by its antecedent in (5-47) because the subject *is not* of the same type as the moved X^0.

Given this *sensitive* context (as the antecedent-trace's relation to antecedents and intervening categories), Rizzi (1990) proposed this groundbreaking and still ruling condition:

Relativized Minimality (RM) (Rizzi, 1990)

A antecedent-governs B only iff there is no C such that
(i) C is a typical potential antecedent-governor for B,
(ii) C c-commands B and does not m-command A.

and (as a corollary)
Antecedent-government:

(i) A and B are co-indexed
(ii) A c-commands B.
(iii) No barrier intervenes.
(iv) Relativized Minimality is respected.

The concept *intervene* describes the intervening element is the one that c-commands the trace and is c-commanded by the antecedent. Notice that a typical potential governor for the trace X^0 category is another X^0 category.

In recent years that system has been refined by Rizzi (2001) and has been shown to be able to handle some problematic apparent exceptions. This result is due in great part to the development of an analysis in terms of a *fine grained featural* composition of syntactic elements, instead of a simpler A/A' distinction[125].

The revised version of RM (from Rizzi, 2001) implies the question of the sensitivity of the principle rely on the definition of "same structural type":

Y is in Minimal Configuration (MC) with X iff there is no Z such that
(i) Z is of the same structural type as X, and
(ii) Z intervenes between X and Y.

A (re)definition of RM is provided also in Chomsky (1995) by the formulation in (weak) derivational terms of RM: the Minimal Link Condition.

Minimal Link Condition (MLC) (Chomsky, 1995):

K attracts a only if there is no b, b closer to K than a, such that K attracts b.

In bare terms, MLC says that intervening elements are defined in terms of *identity* of features.

Even in the Cartographic approach of Rizzi (2001) each of the (newly discovered) positions can be defined by its particular set of morpho-syntactic features (and such features can be catalogued in virtue of the "class" they belong to), but in virtue of a fine-grained taxonomy of positions, Rizzi (2001) is able to derive a definition of "same structural type" (namely, a *Specifier licensed by features of the same class*) which permits to avoid the excessive freedom generated by the MLC (pointed out often in the recent literature).

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[125] As Rizzi points out, while a distinction in terms of A vs. A' has turned out to be too *narrow* (the derivational approach of Chomsky (1995) MLC is considered to be too *broad*. It has been noted, for example, that quantificational adverbs and negation differ in featural make-up from wh-elements but they do interfere with them (Rizzi, 2001). This puzzle is solved by Rizzi considering the results of the *Cartographic Approach* (in some ways, a topological approach), the attempt to draw maps as detailed and precise as possible of syntactic configurations (see Belletti, 2002; Cinque 2001; Rizzi, 2002).

Rizzi shows that the cartographic studies offer a range of (functional) positions which one can continue to define as A' for convenience, but which can provide us with the needed distinctions (cf. Also Garraffa and Grillo, 2007 for a very interesting attempt to apply RM to agrammatism).

Given the above revised formulation of RM (Rizzi, 2001), we expect RM effects only between features of the "same structural type" (that belong to the same class), but not among features that belong to different classes.

It is clear that inside a graph theoretic perspective RM effects involve *edge*s and the features expressed by them.

An interesting fact that confirms the intuition in Rizzi (2001) is reported in Hornstein *et al.* (2005). The following example (adapted from Koopman (1984) by Hornstein *et al.* (2005: 170) shows that minimality seems to be tuned to features rather than positions. In fact we may find cross-linguistical instances of intervening positions of the same type that do not induce intervention effects. Koopman (1984) has argued that a focused verb in Vata moves to C°, leaving behind a copy, as illustrated below, where the verb li (eat) is focused.

Vata

(5-48) (Koopman, 1984)

a. li à li-da zué sakà
eat we eat-pst yesterday rice
"We ATE rice yesterday"

b.li O da saka li
eat s/he aux rice eat
"She has EATEN rice yesterday"

The verb *li* moves to C° from the Infl-adjoined position in (a) or from its base position in (b). Leaving aside the reasons why the trace in phonetically realized (anyway, an interesting fact), what is relevant here is that in (b) the main verb moves to C°, crossing the auxiliary *da* in Infl position. Thus, without raising a RM violation[126]. If we assume that RM takes *features* (in example Focus features in (5-48)) instead of positions as a trigger/syntactic alarm, the acceptability of (b) is explained.

This in a hint, that shows that RM can be computed with respect to features/functions. In the present proposal, features/functions are inhabitants of the graphic edges. I try to formulate a congruent principle based on the discussion above.

[126] That would be unexpected under the HMC, subsumed under RM, for a head is moving to a head position skipping an intervening head position (cf. Hornstein et al. 2005).

RM in syntactic graphs:

Let v (a lexical item) contain a selectional (or sub-categorizational) requirement for v′, than the cluster (v,$e^{(f)}$,v′) in established only if there is no feature/function f expressed in an edge (e) at PF such that, given a lexical item v′′ adjacent to v′ and transitively preceded by v, f triggers for a cluster (v,$e^{(f)}$,v′′).

This is a kind of a *minimal configuration* for graphs. Such a consideration implies that we must necessary postulate a relation different from sub-categoriazion/selection (in example following Bowers (2001) we need a relation of *modification* (cf. also Rubin, 1996), such as for the relation that link nouns and attributive adjectives)), otherwise the principle sketched above would be ruled out.

Given the linearity of our proposal, the statement above could seem trivial, but I think that postulating such conditions is quite natural in a label (level) free theory; as representations are definitely simplified here, "derivational" constraints have to become more articulated. Note that all the conditions proposed here are extremely local. Theoretically, in my (weak) derivational interpretation (see below for a discussion), syntactic structure is the result of the interaction of properties of lexical items and (the set of) local (economical) operations among them.

5.8 Pro Kayne

After Rizzi, let consider the work of another ἀπὸ μηχανῆς θεός of contemporary syntax, Richard Kayne.

Trivialising his Linear Correspondence Axiom (LCA) developed in the framework of Antysymmetry, it reduces to the statement that there is only one *word order* available in Universal Grammar. The core of this theory is that hierarchical structure in natural language maps universally onto a particular surface linearization, namely *specifier-head-complement* branching order.

The theory is based on a notion of *asymmetric c-command*. Asymmetric c-command is simply the relation which holds between two categories, A and B, if A c-commands B but B does not c-command A. This relationship is a *primitive* in Kayne's theory of linearization, the process which converts a tree structure into a flat (*structureless*) string of terminal nodes. Very informally, Kayne's theory states that if a non-terminal category A c-commands another non-terminal category B, all the terminal nodes dominated by A must precede all of the terminal nodes dominated by B (this statement is commonly referred to as the "Linear Correspondence Axiom" or LCA).

Kayne notes that his theory permits either a universal *specifier-head-complement* order or a universal *complement-head-specifier* order, depending on whether asymmetric c-command establishes precedence or subsequence (S-H-C results from precedence) (Kayne, 1994: 35-36). Kayne argues that there are good empirical grounds for preferring S-H-C as the universal underlying order (cf. chapter 3), since the typologically most widely attested order is for specifiers to precede heads and complements (though the order of heads and complements themselves is relatively free).

Furthermore, Kayne argues that a *movement* approach to deriving non S-H-C orders is appropriate, since it derives asymmetries in *typology* (such as the fact that "verb second" languages such as German or Dutch are not mirrored by any known v*erb second-from-last* languages)[127].

I know that my proposal for a graph inspired syntactic theory can hardly be *enhanced* by the groundbreaking observation of Kayne (the whole minimalist framework has *The Antisymmetry of Syntax* as a milestone). The proposal developed here is a linear theory, and this is a very minority position in the contemporary linguistic panorama[128].

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[127] It is interesting to notice that a weak version of the theory of antisymmetry (Dynamic antisymmetry) has been proposed by Moro (2000) allowing the generation of non-LCA compatible structures (points of *symmetry*) before the hierarchical structure is linearized at PF. The unwanted structures are then rescued by movement: deleting the phonetic content of the moved element would neutralize the linearization problem. (cf. Moro, 2000). From this perspective, Dynamic Antisymmetry aims at unifying movement and phrase structure which would otherwise two independent properties that characterize all and only human language grammars.

[128] A *linear syntax* is pursued in the framework of Head-Driven Phrase Structure Grammar (HPSG) (for and introduction cf. Pollard and Sag, 1994) Linearization theory was first introduced by Reape (1993, 1996), who proposed a (topologically inspired) feature called *DOMAIN*. *DOMAIN* values were lists of signs, which had independent ordering constraints, from which the phonology of a sign was derived. The original work by Kathol (2000), combines *DOMAIN* and traditional notions of topological fields to explain a variety of phenomena in German. In his formulation, topological fields are primitives in the ordering constraints of clause-level DOMAIN lists. This approach allows insights into German (and Dutch) syntax which depend on linear order rather than tree structure to be captured in HPSG.

The core of the HPSG framework rests on making an *a priori* distinction between *strong* and *weak* linearity:

a. *Weak linearity*: Grammatically predictable linear relations holding among a set of linguistic constituents.

b. *Strong linearity:* Grammatically unpredictable linear relations holding among a set of linguistic constituents.

These definitions are deliberately vague in many respects in order to be as theory independent as possible. For example, the term *constituent* should be understood broadly to

Anyway a light (*loose*) version of LCA is congruent with our proposal: interpreting some of the key-points of Kayne (1994), we may say that any utterance (or a syntactic graph) establishes a *precedence* order imposing a timed sequence on the items in U: {U=v,e; v′,e′; v′′,e′′… v^n,e^n}. Following Kayne (1994) a precedence order is a principle (→) that is:

a) *total*: for any pair (v,e); (v′,e′); in U; either (v,e) → (v′,e′) or (v′,e′) → (v,e)
b) *anti-symmetric*: there is non pair (v,e) (v′,e′) in U such that (v,e) → (v′,e′) and (v′,e′) → (v,e)
c) *transitive*: if (v,e) → (v′,e′) and (v′,e′) → (v′′,e′′), then (v,e) → (v′′,e′′)

This consideration in somewhat self-evident and leaves out the real question answered by Richard Kayne ("How a hierarchical structure parses words into a meaningful sentence?"). The above mentioned self evidence emerges because the tentative model developed here does not postulate any substantial differences between *time* (or the observable order in which words are pronounced) and *syntax* (that is assumed as linear, instead of hierarchical).

5.9 Derivationalism and Graph Theory

The input for the formulation of such an hypothesis has been a graph(ical) representation, so one can argue that a syntactic graph account needs to be *representational* by nature (also admitting a top-down dynamic process given the principles in 5.2.2, with particular regard to the Directionality Principle (Root Principle) and the Edge Prioritized one. Furthermore, the principles given in 5.2.2 are representation-driven[129]. Anyway if we assume syntax as a recursion of the minimal syntactic clusters (*v,e*) as in (5-16) a (weak) derivational approach for the graph hypothesis is not ruled out *a priori.*

The quarrel between derivation vs. representation leads to interesting and opposite viewpoints (there is a whole stimulating volume "Derivation and explanation in the Minimalist Program" edited by Epstein and Seely (2002) that tries to address the question). For many scholars representational arguments (in example c-command) seem to be a structuralist *heirloom*.

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mean a phonological, morphological, or syntactic constituent.

[129] Testing all those principles (cross-linguistically) in complex, controversial sentences would turn out to be the *work of a life*. Furthermore, I am sure that I will be to find an *escamotage* for any of the many problems that will, inevitably, come out.

The way Chomsky (1995 and subsequent works) set up the program, based on the computational system of human language, is *derivational* by nature, proceeding bottom-up by successive application of the operation Merge with items first taken from the lexicon (the numeration or *lexical array*), and then with items already merged (by Move or, following the seminal work of Starke, 2001, *another kind of* merge). Under the *copy theory*, syntactic objects are copied and re-merged, followed by deletion of the lower copy (presumably for PF-reasons; see Hornstein *et al.* 2005 for a detailed introductory discussion).

Notice that in a "standard" view of movement, Move (or Copy plus Merge) creates a *chain*, which contains the moved element and its copy/trace (cf. Grohmann 2003).

This aspect of the computational system of human language, in particular, is suspect for defenders of a *representational* nature of language, casting doubt on the hybrid character of the system to derive dependencies and also represent them on the grounds of a very basic minimalist principle: economy.

It should be noted, anyway, that not all minimalist work assumes chains as components of the computational system of human language (cf. Hornstein 2000). In an attempt to summarize things, we may distinguish among a strong derivational approach: *There is no (final) representation and everything is computed dynamically* (the approach of Epstein and Seely, 2002); a weak derivational approach: *Some operations are cyclic, but others apply at the interface to the entire expression* (Chomsky 1995, 2001a) and a representational approach: *there are no derivations, all conditions apply to LF/PF representations* (Brody, 1997).

Finally, it is interesting to notice that the principle of *inclusiveness* (cited here in Chapter 3) is massively violated worldwide by phonological components (by adding prosodic structure, *narrow* phonetics). Perhaps, the source of these imperfections is our *sensorimotor* system.

5.10 Copula as a functional device; Copula and Nominal Modifiers

The recent (and elegant) unified account for copular sentences made by Dan Dikken (2005), following Moro (1997, 2000) perfectly fits our interpretation of facts. Den Dikken argue that all copular sentences *involve* a small clause, with even the so-called equative copular sentences being underling predicational (see the set of empirical evidences in Den Dikken, 2005: chapter 3). The conclusion made by Den Dikken substantially reduces the typology of copular sentences types: *underlyingly there is just one type of* *copular sentences*, not the four types recognized in Higgins (1979), reported in Den Dikken (2005: 77) and reproduced below:

(5-49)
a. Brian is a clever guy (predicational)
b. Brian is the culprit; The culprit is Brian (specificational)
c. Brian is the man over there; the man over there is Brian (identificational)
d. Cicero is Tully; Tully is Cicero (equative)

If, according to Den Dikken (2005) all copular sentences are underlying predicational, hence all, traditionally, have to include a small clause in their syntactic structure, and the fact that all small clauses include a functional head (cf. Den Dikken, 2005: 62) then "leads to the conclusion that copular sentences (of all types) should features a *linker*" (Den Dikken, 2005). This is relevant for the present theory because *all copulas can be considered as edge-linking operators that carry a predicational feature*.

I have taken the *zero* copula as an hint for the widespread possibility of edge content deletion. We may see, anyway, that the linguistic *spectrum* is quite ambiguous. Russian and Maltese for example are languages in which a zero copula is used in the present, whereas a full copula is mandatory for all other tenses. This is not a problem for our proposal; other (not the default set?) features may act as triggers for the presence of copular items.

Russian

(5-50)
a. ona vrap
she doctor
'She is a doctor.'

b. Moskva gorod
Moscow city
'Moscow is a city.'

c. on byl upenik-om
he be.m.pst pupil-instr
'He was a pupil.'

Maltese

(5-51)
a. Albert tabib
Albert doctor
'Albert is a doctor.'

b. Albert kien tabib
Albert be.3sg.m.pst doctor
'Albert was a doctor.'

Then, it is relevant to underline that there are other linguistic ways (using different strategies and items) of encoding predication.

An important cross-linguistical fact is that a frequent type of split encoding involves a contrast between a full supporting verb for locational predication and the absence of any overt linking item (a *zero* copula) for nominal predication. Following Comrie *et al.* (2005) examples of split-languages in which this situation holds are Mokilese (Oceanic; Micronesia) and Waskia (Madang; Papua New Guinea)

Mokilese

(5-52) (Harrison 1976: 142, 209)

a. John johnpadahk-men
John teacher-indef
'John is a teacher.'

b. ih mine Hawaii
he be Hawaii
'He is in Hawaii.'

Waskia

(5-53) (Ross and Natu Paol 1978: 11, 12)

a. aga bawa taleng-duap
my brother police-man
'My brother is a policeman.'

b. kadi mu kawam se bage-so
man art house in stay-3sg.pres
'The man is in the house.'

Another variant of split encoding is based on the difference between a full support verb for locative predicates and a verbal encoding for nominal predicates. Since there are not that many languages in which predicate nominals are treated as *verbs* anyway, it will be clear that this variant of split encoding will be less frequent than the other. An example of this encoding option is Austronesian language spoken in the Philippine, Kapampangan: as is shown by sentences (5-54a-b), predicate nouns in this language have the same morphosyntactic properties as predicate verbs. Austronesia languages are, as often, very puzzling (Tagalog and Malagasy are the most studied instances).

Kapampangan

(5-54) (Mirikitani 1972: 137, 44, 72)

a. tinerak ya ing anak ku
dance 3sg art child my
'My child danced.'

b. mestro ya ing lalaki
teacher 3sg art boy
'The boy is a teacher.'

c. ati ya ing lalaki king eskwela
be 3sg art boy at school
'The boy is in school.'

There are, on the other end of the linguistic continuum languages that share status on the basis of a *zero-zero* encoding. One such case, reported in Comrie *et al.* (2005) is Pitjantjatjara (Pama-Nyungan; South Australia).

(5-55) Pitjantjatjara (Douglas 1959: 55, 81)

a. *wait ngalyayala*
man doctor

'The man is a doctor.'

b. *tjitji kutjara ngura-ka*
child two camp-at
'The two children are at camp.'

Therefore, interesting facts emerge also from studies made on creoles and pidgins:

"While studies of the verb phrase made clear the Atlantic creoles' structural similarity to one another and autonomy *vis-à-vis* their superstrates, it was the first comparative studies of the various words for 'be' in creole and African languages that unequivocally demonstrated that the creoles were not merely *simplified* forms of European languages. These studies showed that the creoles were in some respects more complex than their lexical source languages in that they made certain grammatical and semantic distinctions not made in the European languages. Many languages often use quite different words for 'be' depending on whether the following structure is a noun phrase, an adjective or an indication of location" (Holm, 2000: 176).

An interesting case in a *bickertonian* sense of linguistic (re)complication: in creoles functional elements raises independently from their lexical superstrates. This is a fascinating fact for the present hypothesis. At least, beyond the importance of substrate influence on the copula systems of the (Atlantic) creoles, this comparison makes clear that creoles are not *merely* simplified forms of their superstrate languages.

Furthermore, *traces* from sociolinguistics also give us interesting suggestions. Labov (1969) found in a quantitative study that African American Vernacular English had a kind of pattern for "deleting the copula" depending on the following syntactic environment (in example, Labov found a low rate of deletion before nouns, a higher one elsewhere, etc.).

A challenging question concerns a peculiar environment for the copular items. A premise: it is cross-linguistically quite rare for the modifiers of a noun to be separated from the noun they modify, but it does happen. Take the following Italian (but English also would have been a possibility) examples:

(5-56)

a. La nostra situazione è drammatica
The our situation is dramatic

"Our situation is dramatic"

b. La nostra è una situazione drammatica
The our is a situation dramatic
"Ours is a dramatic situation"

c. Questa è la nostra situazione drammatica
This is the our situation dramatic
"This is our dramatic situation"

d. La nostra situazione drammatica è ridicola
The our situation dramatic is ridiculous
"Our dramatic situation is ridiculous"

Within a (more) traditional framework, I will interpret the set in (5-56) as the demonstration of the movement of the copula within a variety of functional projections (cf. also Zamparelli, 1995) in the (complex) noun phrase (as for attributive adjectives in the example above, following Cinque (1994)).

Another evidence is found in Croatian and Serbian (South Slavic), the verb *je* 'is' must occur in second position in a clause. What is unusual in this situation is that second position (sometimes known as *Wackernagel's position*) may be defined as being after the first NP in the clause or after the first word in the clause. The two possibilities are exemplified in (5-57), from Barac-Kostrencic *et al.* (1993), reported in Van Valin (2003: 118).

(5-57)
a. Naˇs-a uˇcionic-a je udobn-a. Croatian
our-fsgnom classroom-fsgnom be.3sgpres comfortable-fsgnom
"Our classroom is comfortable."

b. Naˇs a je uˇc ionica udobna.
our is classroom comfortable
"Our classroom is comfortable."

In (5-57a) the verb *je* 'is' occurs after the subject NP, another form is attested in (5-57b), in which *je* 'is' appears between *naˇsa* (our) and *uˇcionica* 'classroom', thereby separating the specifier from its head. Functional projections are needed. Furthermore it is important to notice that, while in Italian there is a semantic fine grained difference among the sentences in (5-

56); see the distribution of determiners), in Croatian and Serbian the utterances in (5-57a,b) mean *exactly* the same thing.

In a graph based account is possible to say that given a set of lexical items *mutually* selected in a series (in example: a noun and attributive adjectives, that share a *modificational* relation), the emergence of the linker is allowed within one of the edges among them. Symmetrically, nothing *a priori* rules out the possibility of a linker to be repeated; obviously we have Ezafe morpheme in mind. Note that, within this idea, by the principles given in paragraph 5.2.2, *all* the set of grammatical operations can fit *any* edge.

5.11 Dramatic examples of Long-Distance Modifiers

The copula that occurs between N and D in Croatian (or N and A in Italian) is an example of a *distant* (layered) relationship. Even more problematic examples of modifiers separated from their noun-heads can be found in other languages. I represent here two exotic examples based on the discussion made in Van Valin (2003: 88) for Australian Aboriginal languages Kalkatungu and Yidi. Such *pairs* are definitely critical for linguistic theories:

Kalkatungu

(5-58)
a. Na-ci japacara-tu kula-ji laji tuar-Ø malta- Ø.
1sg-dat clever-erg father-erg kill snake-abs mob-abs
'My clever father killed the snakes.'

b. Na-ci kula-ji laji tuar-Ø malta-Ø japacara-tu.
1sg-dat father-erg kill snake-abs mob-abs clever-erg
'My clever father killed the snakes.'
(#My father killed the clever snakes.)

Yidi

c. Nayu nunu-Ø munil-Ø wawa-:l.
1sg-nom that-abs vine-abs see-past
'I saw that Munil vine.'

d. Nayu nunu-Ø wawa-:l munil-Ø.
1sg-nom that-abs see-past vine-abs

'I saw that Munil vine.'

The dative case is used to mark possession in Kalkatungu (5-58a,b). Both of these languages have free word order (in example free ordering of NPs and PPs with respect to each other and to the verb), which is not uncommon cross-linguistically (cf. again tWAoLS edited by Comrie *et al*. 2005), but they also allow the modifiers of a noun to occur separated from the noun, which is quite unusual; this may be termed (really) "free word order" (*non-configurationality*, adapting Kenneth Hale (1983) terminology; cf. also Jelinek, 1984). In the (5-58b) in Kalkatungu, the adjective *japacara* 'clever', which modifies *kula* 'father', appears at the end of the sentence separated from it by the verb and the *absolutive* NP *tuar*. Because modifiers agree with their head in Case, there is no possibility of interpreting this sentence as meaning that "snakes are clever", not the father; indeed *japacara-tu* 'clever-erg' has an ergative case suffix in these sentences, indicating that it modifies *kula-ji* 'father-erg', which is also in the ergative case, and not *tuar-Ø* 'snake-abs', which is in the absolutive case.

The things in the Yidi example are quite the same: *a noun modifier occurs separated from the noun it modifies*. In (5-58d) the demonstrative *nunu* 'that' precedes the verb, while the noun it modifies, *munil* 'Munil vine', follows the verb; they agree in case (cf. Van Valin, 2003).

Thus, it is possible in some languages for a modifier to appear separated from the head noun it modifies; in Kalkatungu and Yidi (and in many other languages as well) the modifier and its head noun may appear in different parts of the clause separated by a number of other elements (cf. again, Van Valin, 2003 for a more detailed discussion and examples from other languages).

Thus, while syntactic relations between modifiers and the item modified *typically* involve adjacency, they do not always require it.

An explanation for that long-distance modification may be that the some features (in example [extensive use of] Case on modifies) *allow* to retrieve "previously spelled-out material", but this is definitely another controversial point.

5.12 The Cartographic Legacy

As we have already seen, the cartographic approach to syntactic structure is characterized by the assumption that inflectional morphology (or the corresponding features) and discourse-related features, such as topic and focus, are *distributed* in the syntax and that these *functional* elements project their own phrasal categories. Thus *core* functional categories like CP, IP and DP actually all have a much more articulated internal structure, as proposed by Rizzi (1997) and Cinque (1999) among others.

Even if it could seem somewhat strange, such an approach has been the very first important *trigger* for the development of my current proposal, for which I have tried to condense/compress the variety of positions described in the cartographic works in a prototypical *monistic* habitat: the edges of a syntactic graph model.

The most important (indirect) influence for my work probably has been the (proto)cartographic proposal of Cinque (1994) of a set of functional heads XPs between N and D, with the generation of APs in those XPs specifier positions. See (5-59).

(5-59) [$_{DP}$ Le [$_{XP}$ sue [$_{XP}$ due [$_{XP}$ altre [$_{XP}$ probabili [$_{XP}$ goffe reazioni [$_{XP}$ immediate [$_{NP}$ *t* alla tua lettera]]]]]]]]
(Cinque, 1995: 296)

This consideration is used by Guglielmo Cinque to explain in an unified way the different surface positions of adjectives in Germanic vs. Romance languages:

(5-60)
a. [D..[AP Y [AP N]]] Romance
|______|
b. [D..[AP Y [AP N]]] Germanic   (Cinque, 1995: 287)

I used Cinque's *substrate* for the account I have articulated for Persian Ezafe in my MA thesis (Franco, 2004).

The need for a more simplified account has taken me to the current *driftage*.

5.13 *Last but non least:* Prepositions and the Ezafe *criterion* in Persian

A final remark. Traditionally, Persian prepositions are divided into two main classes with respect to the Ezafe linker: *Class 1* (abbreviated C1 Ps) and *Class 2* (abbreviated as C2 Ps). Lazard (1992) and other authors agree that the first class of prepositions are *true* prepositions, since they never take the Ezafe linker.

A fact against this assumption has been consider (Samiian, 1994, Pancheva

2005) by the possibility of Class 2 prepositions to be further divided into two subclasses: *Class 2a* containing prepositions with optional Ezafe, and *Class 2b* containing those with obligatory Ezafe. I have already expressed in Chapter 4 my point of view.

Summarizing from Chapter 4, Samiian (1994) gives a description of the distribution and function of the Ezafe vowel in Persian and provides a unified syntactic account in terms of a formal system of features. She states that Ezafe is a dummy Case assigner (similar to English *of*, Italian *di*) which appears within phrases headed by non-case-assigning categories, thus enabling them to Case-license their complement.

This assumption provides a straightforward explanation for the presence of Ezafe before attributive nouns, but doesn't account for the Ezafe vowel before attributive adjectives, since it is not clear why in Persian attributive adjectives need Case (even if she points out similarities with Latin and Sanskit). Anyway, she found a way, following Stowell's Case Resistance Principle[130], and assuming that non-case-assigners need case, whereas case-assigners do not (cf. also Pantcheva, 2005 and Larson and Yamakido, 2005). Given this, the question arises why most prepositions in Persian take their *complement* via Ezafe. Since verbs and prepositions are both Case-assigners by virtue of their [−N] feature, the latter are not expected to need some *special device* for taking a complement?

The whole story is pictured in Chapter 4. The interesting (and basic) thing here is that Ezafe linker provides an empirical *criterion* for classifying Persian prepositions. Traditionally they are divided into two classes, the members of which manifest differences in their syntactic behavior:

• Class 1 Prepositions – *reject the Ezafe morpheme* (*be* 'to', *dær* 'at', *æz* 'from/via', *ta* 'up to', *bær* 'on')

• Class 2 Prepositions – *allow Ezafe when followed by a complement* (*ru*(-ye) 'on', *zir*(-e) 'under', *posht*-e 'behind', etc.). This class is fairly open and contains many items. A relevant fact is that diachronically (cf. Lazard, 1992), C2 Ps have originated from *nouns* and some of them still exist as real nouns.

An illustration of the *unavailability* of the Ezafe vowel on C1 Ps and its

130 Stowell (1981) tried to derive the distributional properties of sentential complements from his Case Resistance Principle: categories whose heads are case assigners resist case assignment, while categories whose heads are not case assigners allow it.

grammaticality with C2 Ps is shown in the following minimal pair in (5-61).

(5-61)
a. * æz $_{C1}$-e   khar
    from-ez donkey

b. zir$_{C2}$(-e) khar
  under-ez donkey

A puzzling fact, shown very well in Pantcheva (2005), is that in the linguistic literature, there are many disagreements as to whether certain prepositions should be classified. I am not a native speaker of Persian, thus I am not able to point out a (very own) point of view. Furthermore, I have not tested intensively this linguistic fact among Persian speakers. By the way, my very first (an most important) informant (and her family, with an exception) seems to suggest that Ezafe morpheme is somewhat *optional* in the whole C2.

This fact is congruent with the present idea concerning syntactic graphs. If C1 is represented by (real) functional elements, while C2 is a collection of lexical items historically derived from nouns (if we also admit that they can derive from *adverbs* (cf. Samiian, 1994), things do not change)), the Ezafe morpheme is a linguistic *fact* that show a paradigm.

I conclude with a(nother) self-evidence:

An edge cannot be adjacent (linked) with another edge.

6. Conclusion

In this work I have tried to outline a new way for the interpretation of syntactic structures. At the basic level, I have proposed a new formalism, derived from topology (broadly) and from Graph theory (more specifically). At a higher level, this work attempts to give other perspective to the economical principles of Minimalist Theory (cf. Chapter 5) and, also, to (re)define an interdisciplinary approach to syntax (cf. Chapter 1; I am in debt with the fascinating works of Searls (2002) and Piattelli Palmarini and Uriagereka (2004)). My involvement (as a student) in the field of Medicine and Surgery (even if *in nuce*) probably is responsible of some *detours*, but I think that this thesis, even where covering lateral, or multidimensional issues, has an internal coherence, at least trying to link my proposal to a general *wave* of works related to "topologies among cognition (and biology)" in the last few decades.

Many questions and problems could (and should) arise and I think that I would have to work at a dozen of thesis to reach some deep (and non-contradictory[131]) results. By the way, it would be interesting to test this formalism and the edge-linking theory developed here in Chapter 5 with a broad spectrum of syntactical issues, because I think that it would be a pity if this research's leading to a… branch with fallen leaves.

The point of departure for my work has been Collins (2002) thoughts on Bare Phrase Structure (BPS) and BPS has been a *trigger* for a series of reasons, which may link this theoretic approach to the idea of syntactic graphs (other than *classical* X' trees):

(i) BPS structure is derivational. That is, it is built from the bottom up, bit by bit. X-Bar Theory, on the other hand, is representational. That is, a structure for a given construction is built in one fell swoop, then the lexical items are inserted into the structure.

(ii) BPS does not have a preconceived structure, while in X-Bar Theory, every phrase has a specifier and a complement.

(iii) BPS has only binary branching while X-Bar Theory permits both binary and unary branching.

(iv) BPS does not distinguish between a "head" and a "terminal".

[131] …but Godel teach us that it is a hopeless quest!

In particular, further developments for a graph theoretic (re)analysis could include the interpretation of the notion of chomskyan *Phases*. Indeed, a phase could be interpreted as a self-contained subsection of a derivation, beginning with a numeration and ending with Spell-Out. Movement of a constituent out of a phase is (in the general case) only permitted if the constituent has first moved to the left edge of the phase. This condition is specified in the *Phase Impenetrability Constraint* (Chomsky, 2000) and phases are assumed to be C and *v.*

Personally, I do not agree with a syntactic computation based on "incremental chunks", because, in my opinion, the computational system must be able to *retrieve* "previously spelled-out material" to provide a complete, coherent surface string (cf. the presence of bidirectional case marking functional words in West African languages, discussed in chapter 5… and there are so many other problems pointed out in the recent literature). Anyway, it would be interesting to try *phases* applications in a graph theoretic perspective, even to find new arguments against them.

A more productive research probably could concern *morphology*, turning out the formation of words and lexical compound selection in a generative perspective (from Aronoff (1976) and Selkirk (1983) to Halle and Maranz (1994). I believe that a *selectional* approach based on a network model (for examples considering suffixes and affixes as edges and *stems* as vertexes) would lead to an economical and elegant representational (or *weakly* derivational) result.

Appendix A

Charles Sanders Peirce's existential graphs

Charles Sanders Peirce (1839-1914) is of seminal importance for modern thought. He is generally regarded as the founder of philosophical pragmatism, and, with Saussure, of modern semiotics. He was also deeply absorbed by linguistic researches throughout his life, learning languages in remote areas while travelling on *geodetic* surveys.

Charles Peirce's contributions to logical theory are numerous and profound[132]. His work on *relations* building on ideas of De Morgan influenced Peano, Russell, Lowenheim and much of contemporary logical theory. Although Frege anticipated much of Peirce's work on relations and quantification theory, and to some extent developed it to a greater extent, Frege's work remained out of the mainstream until the twentieth century (Proni, 1992). In contrast to Frege's highly systematic work in logic, Peirce's work remains fragmentary and extensive, rich with profound ideas but most of them left in a rough and incomplete form (Proni, 1992).

In this appendix, without aiming to give any novel contribution, I am going to make a brief presentation of one of the Peirce's contributions[133] to logic that is not as well-known as others: *Existential Graphs*. Peirce's logic[134]

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[132] Peirce's logic theory tries to explain this quality of mind: how our feelings (intuitions) become effectively related to what (without this mediation capability) would be the brute-force objects in a world of simple reaction, by means of our power to contemplate and converse, which makes it possible for us to "know" (to gain some control of what happens in our experience). Self-critical, collective reasoning is the scientific method—and science is not a body of certified truths or systematized knowledge. He even suggested that knowledge is not the point of science at all: knowledge though systematized may be dead memory (hide-bound). The scientific inquirer is a member of a community of those who disinterestedly pursue the truth, which none can know as a matter of fact and must be conceived as an ideal or limit (cf. Keeler, 2004 for futher details).

[133] Another important contribution is Peircian Calculus of relations. Briefly Peirce fruitfully applied the concepts of Boolean algebra to relations. Boolean algebra is concerned with operations on general or class terms. Peirce applied the same idea to what he called "relatives" or "relative terms." While his ideas evolved continually over time on this subject, fairly definitive presentations are found in Peirce (1870) and Peirce (1883), for which I have the Italian edition (see bibliography). The calculus of relatives is developed further in the work of Tarski (cf. Proni, 1992).

[134] Placing the Existential Graphs within Peirce's philosophical context requires a tremendous work. Although 10,000 pages of his scientific work were published during his lifetime, most of his philosophical writings (100,000 manuscript pages archived in the Houghton Library at Harvard) remain unpublished, except in 30-year-old microfilm. The misleadingly named *Collected Papers of Charles Sanders Peirce* (eight volumes published 50-60

has definitively been an “underground trigger” for my work, even if there are no direct parallelisms or intersections.

Peirce developed his “existential graph” as an intermediate formalism between mathematical logic and topology (cf. Proni, 1992).

The basic ideas of Peirce’s system is that every *utterance* may be inscribed on an *abstract utterance sheet*. The absolute terms are represented by *dots* on the sheet. If two dots are referentially identical they are *joined* by a *line*. The negation of a dot is represented by a *closure* which contains the dot. Them as no general geometrical pattern is presupposed, a dot can be placed anywhere. Relations between concepts (*schemata*) are represented by relational graphs with different valences. Peirce sought a “user-friendly” symbolic environment, and came up with his system of Existential Graphs (cf. Proni, 1992).

Thus, an existential graph is a type of diagrammatic or visual notation for logical expressions. Following his development of quantification theory, Peirce developed a graphical system for analyzing logical reasoning that he felt was superior in analytical power to his algebraic and quantificational notations[135]. Peirce’s original graphic system consist of three portions (*alpha*, *beta* and *gamma*).

Existential Graphs allow the user to express and manipulate logical statements in a completely graphical way. The system has some straightforward advantages over traditional systems, and the rules for drawing inferences are both quick and easy.

years ago) contains about 150 selections from his unpublished manuscripts, and only one-fifth of them are complete: parts of some manuscripts appear in up to three volumes and at least one series of papers has been scattered throughout seven. A more recent attempt to publish this material, *Writings of Charles S. Peirce: A Chronological Edition* (projected in 30 volumes) has only succeeded in issuing six volumes in twenty-five years of work and, even if the edition is completed, this would represent less than one-third of the entire Houghton collection. Most significantly, the print format cannot easily present his progressively more graphical and colorful work: manuscripts filled with symbols and complicated graphics and crucially meaningful color, in both words and diagrams. He produced his most intensive theoretical work, which includes the Existential Graphs, during the last 10 years of his life (40,000 pages, or nearly half of the whole collection) (Information retrieved from Keeler, 2004) .

[135] Zeman (1997) suggests that in his graphs Peirce is aiming at an iconic, transparent, representation of relationships, a sign that he has identified with clarity and with connection (with an object) through resemblance. In fact, Zeeman goes on to say, the notion of iconicity is directly connected with the mathematical idea of (one to one) mapping and that Peirce aims through his graphs to "map" the important features of mind, and hence externalise reasoning.

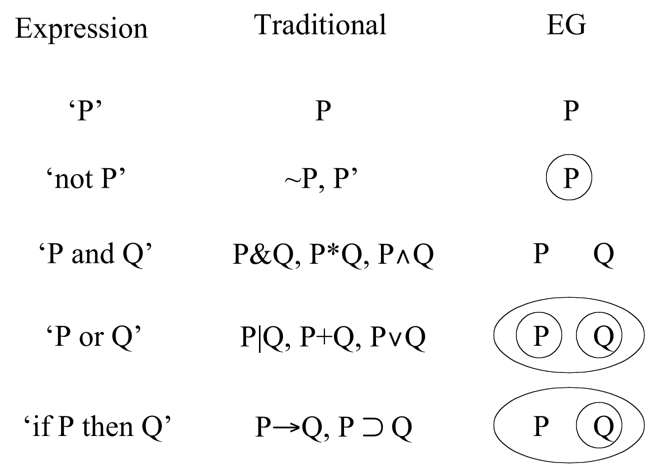

fig. 1-A

As with any logic system, the system of Existential Graphs has two components: symbolic notation and logical inference. Figure 1-A illustrates the notation of Existential Graphs as compared to more traditional notations of the various statements of propositional logic (cf. Keeler, 2004). A number of features of Existential Graphs should become apparent from this:

1. To express any *statement* P, write it on a blank sheet of paper. This sheet of paper is called the *Sheet of Assertion* (SA).

2. To express the *negation* of a statement,(P′ or ~P), draw a circle, oval, rectangle, or any enclosed line-figure around it. This line-figure is called a *cut*.

3. To express the *conjunction* of two statements, simply express each statement separately. For example, to express ‘P and Q’, simply write a ‘P’ and a ‘Q’ anywhere on the SA. This reveals one immediate advantage of Existential Graphs over traditional systems: in traditional systems, ‘P and Q’ and ‘Q and P’ are symbolized in distinct ways, and a separate commutation rule is needed to transform the one into the other. In Existential Graphs, however, these two statements are symbolized in exactly the same way, which is what one would hope, since the two statements are obviously equivalent.

4. To express *disjunction* ('or') or *implication* ('if .. then'), use equivalence laws (such as DeMorgan's laws) to rewrite them as a combination of conjunctions and negations. See below:

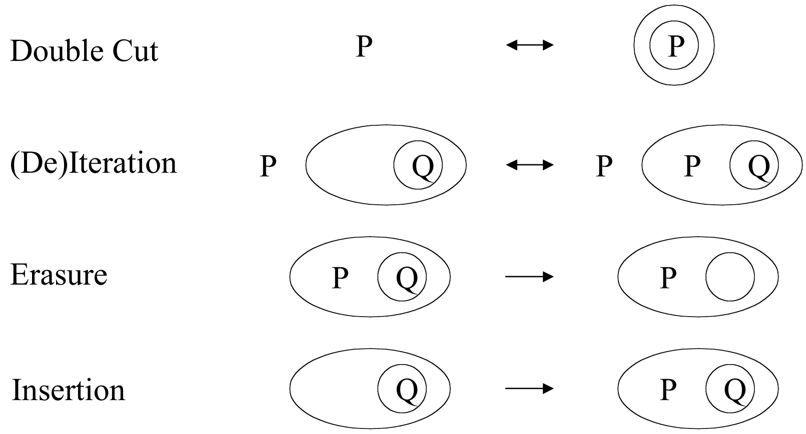

Fig. 2-A

To understand the rules of Existential Graphs, we need to define the *level* of a statement, which is the number of cuts around that statement. Thus, if we symbolize 'not P' by drawing a P with a single cut around it on the SA, then the statement as a whole is said to be on level 0, but the P itself is on level 1. The level of some statement X is said to be *deeper* than the level of some statement Y if one can go from Y to X without ever going outside a cut (but possibly going inside a cut). The rules of Existential graphs are now as follows (see Fig.2-A above for a graphic representation):

i) *Double Cut*: You can draw a double cut (which is drawn as "nested" cuts with nothing in between) around any statement, and any double cut can be removed.

ii) *(De)Iteration*: You can make a copy of any statement at a level that is deeper than the level of the original statement. And, you can remove copies of a statement that exist at a deeper level.

iii) *Erasure*: You can remove any statement from an even level.

iv) *Insertion*: You can insert any statement on an odd level[136].

Despite their simplicity, Peirce's graphs have been ignored by "mainstream" logicians for a long time. Recently, Artificial Intelligence researchers developed *conceptual graphs* -- a synthesis of existential graphs, dependency graphs, and semantic networks (Sowa, 1993). Conceptual graphs are as general as predicate calculus yet are as readable as special-purpose diagrams (i.e. parse trees, *Petri nets*, cf. Chapter 2).

Sowa (1993) shows that conceptual graphs encompass such special-purpose diagrams and can also be translated to the logic system KIF[137] (Knowledge Interchange Format).

In Artificial Intelligence, there are *spaces* that are exploited for work in semantics, databases and natural language processing, for graph and network representations, in genetic algorithms and neural networks and with intelligent agents.

A semantic space is a space that is concerned with meaning. This can be the meaning of sentences (questions, orders, etc.) or the meaning (i.e. subject matter) of books (dictionaries, poetry, fiction, etc.) and so forth (Sowa, 1993).

As we know well, graphs and networks exploit spaces that are defined by symbolic representations used for formalisation. Examples in Artificial Intelligence are the above-cited conceptual Graphs of Sowa and *Extensional Semantic Networks* (Janas and Schwind, 1979) used to represent the literal meaning of sentences. To do this, they use concepts (objects) and relations between them.

Existential Graphs can be used to "express standard propositional logic, first order logic and even modal logics" (Sowa, 1993). Neural networks also exploit graph spaces. Genetic algorithms exploit bit spaces that are occupied by self-selecting programs. These programs, as we know, explore several

[136] The Double Cut rule is normally called Double Negation or Involution, and reflects the obvious fact that 'not not P' is equivalent to 'P'. The other rules of Existential Graphs do not have immediate counterparts in traditional logic systems.

[137] KIF is a logic system with Lisp-like notation designed to be readily mapped to and from computer systems. Conceptual graphs have attracted wide interest and research. Another on-going research projects is PEIRCE, a multi-national effort to develop a "state-of-the-art, industrial strength" conceptual graphs workbench. Taking advantage of the widespread use of graphical workstations, PEIRCE allows developers to "write / draw / parse / learn large conceptual graphs / programs / databases / ontologies" (cf. Ellis 1993).

possible avenues and then select the one with the best yield for further use. Existential graphs could be seen as a *negotiation* space (the SA) defined by the set of interactions between agents and data and other programs[138].

Indeed, Peirce considered deductive logic to be the study of *process* and an empirical science and he saw his graphs as providing a context for experimentation:

> "One can make exact experiments upon uniform diagrams; and when one does so, one must keep a bright outlook for unintended and unexpected changes thereby brought about in the relations of different significant parts of the diagram to one another… Just so, experiments upon diagrams are questions put to the Nature of the relations concerned" (Peirce, 4.530)

Charles S. Peirce's ambition was to ground and expand logic on a fundamentally new basis – a general theory of representation that he called "semeotic" – which could account for the continuous nature of thought and communication operating *mediationally* in human experience to generate knowledge. He was convinced, through his professional work as a scientist, that absolute accuracy is *unattainable*, and his pragmatism regards truth as a *limit* successively approached by increasingly refined investigations, which depend on communication among collaborating investigators (cf. Keeler, 2004).

Peirce's theory has been recognized as a new philosophical perspective responding to (and reconciling the effects of) Cartesian dualism, materialism, and reductionism (Proni, 1992). A chemist by training, Peirce employed the concept of sign to examine conditions that we cannot observe by empirical methods (as we can the structure of a medium and the behavior of participants) the way a chemist employs the concept of molecule as the basis for explaining molecular activity underlying the observable behavior of materials in reaction. "Mediation is not merely reaction; we cannot discover "the rules" of sign-mediated behavior simply by external observation and statistical summary" (Keeler, 2004).

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[138] In psychology (in many frameworks), different kinds of space are used implicitly. Navigational space, manipulation space and view space are three examples of such spaces (cf. Mantovani, 1995). Navigational space implies the ability to move about in an obstructed space, providing different view points and perspectives on objects in the space; manipulation space involves rotating and displacing objects; while view space involves constructing broader overviews from piece-meal micro-views. It is also possible to conceive of memory spaces or other cognitive spaces used to help situate minds in the world. (cf. Chapter 1)

Peirce's Existential Graphs provide a sort of meta-linguistic means of observing the semiotic growth of language, where the existence of anything referred to remains permanently hypothetical (never absolutely confirmed or denied) and only our continued attempts (as pragmatism describes) to make it intelligible are examined as the means by which we understand it in some measure that continues to grow (cf. Eco, 1992). His system of graphs was never finished, and we have only indications of how he hoped it would ultimately contribute to his philosophical perspective. In a letter, he writes:

> "I wish you would study my Existential Graphs, for in my opinion it quite wonderfully opens up the true nature and method of logical analysis; — that is to say, of definition; though *how* it does so is not easy to make out, until I shall have written my exposition of that art. I am now working desperately to get written before I die a book on Logic that shall attract some good minds through whom I may do some real good".

APPENDIX B

The network of Relational Grammar

Relational Grammar (RG) was introduced in the seventies as a theory of grammatical relations and relation change, for example, *passivization*, *raising* and *dative shift*. The main idea behind RG was that transformations as originally designed in generative grammar were unable to capture the common *kernel* of, in example, passivization across languages.

The development of RG can be traced back to the mid seventies. It became apparent at this time that the then current theory of transformational grammar specified the structural changes brought about by operations of relational change in too concrete a detail, whereby missing evident generalizations. For example, it was not possible to state what was common about passives in various languages, since in order to do that one had to abstract away from accidental facts such as word order. If one took grammatical relations as *primitives*, however, a general rule of passive could be formulated directly. All that was required was to state that passive makes the object into the subject, thereby pushing the former subject out of its status. The surface ordering of elements can be handled independently of the relational change.

There exists a collection of papers edited by David Perlmutter, Paul Postal (and Carol Rosen) in two volumes, which survey the research that has been conducted within RG. Some of the criticism of transformational grammar has been overcome with the introduction of the theory of government and binding (GB). Unfortunately, I think that the range of phenomena that RG deals with is far wider than the one GB can handle, and many issues that have been brought up by RG have been *side-stepped*.

Relational Grammar assumes that a sentence is organized using grammatical relations. A predicate can take certain arguments, and these arguments can be distinguished by the relations they bear with that predicate. There are many relations. The central relations from the standpoint of syntax and morphology are *1, 2* and *3*. (cf. the *Introduction* to Relational Grammar Vol. 1 (Perlmutter and Postal, 1981)) . They correspond roughly to the more traditional terms of subject, direct object and indirect object. There are also more familiar relations such as beneficiary, location, instrument. RG assumes that a sentence is organized as a *tree*, where the grammatical relations are annotated. An example is shown in example (1):

(1-B) a. b.

RG assumes that the relational networks are based on rooted directed acyclic graphs (cf. Diestel, 2005). This is so because the structures contain a record of the entire derivation, wich according to RG is necessitated by the fact that syntactic rules are sensitive to the initial stratum and some even to the intermediate strata (cf. Perlmutter and Postal, 1981; see below for a discussion).

For a *rooted directed acyclic* graph we may give the following definition of Kracht (2000):

> (2-B) *Let G be a non empty set and < a binary relation on G. Then the pair (G, <) is called a routed, directed, acyclic graph, with root R, if the following holds: a) for no x: R < x. b) for every x ∈ G there is a sequence x < x1 < x2 <… <xn = r. c) there is no sequence x0 < x1 <… <xn-1 <x0, n > 0.*
>
> *The pair (G, <) is a tree if in addition for each x there exist at most one y such that x<y. x is a leaf if there is non y such that y < x. If x < y then x is a daughter of y and that x is the mother of x.*

Now we may define a *relational graph*, again following Kracht (2000):

> (3-B) *let T be a set. A relational graph over T is a quadruple (G, <, p, L) where:*
>
> *i) (G, <) is a tree*
>
> *ii) p is a function from < to T*
>
> *iii) L is a function from the lexicon to the leaves of (G, <).*

There are certain appropriateness conditions on these relational graphs, with have to do with the *valency* of a predicate. We have to assume in RG that the lexicon specifies how many and what kind of sisters a predicate can have (cf. Perlmutter and Postal, 1981).

Consider again the example in (1-Ba). Here *kills* is the predicate; *Gianni* bears the 1-relation and *the cat* the 2-relation with the predicate. As sentences can also assume relations with predicate, the structure is recursive.

I believe that RG shares with Universal Grammar the assumption that grammatical relation are *lifted* (changed) in the process of derivation, but RG assumes that syntax is sufficiently modular for allowing a relational approach. RG is driven by the thought that relational change is all that happens in a derivation, while, i.e. word order is solved at surface structure only (cf. Perlmutter and Rosen, 1984 and Harris, 1981 for more details).

The (proto)typical instance of an operation that changes relations is the passivization operation. The passive morphology on the predicate has as its effect that the constituent previously bearing the 2-relation with the predicate, now bears the 1-relation, as in the example (1-Bb).

RG tells that 2 is *advanced* to 1 (cf. Perlmutter and Postal, 1981). It would be possible to expect that in (1-Bb) there are two items (constituent) bearing the same relation, but RG formulated a *law* that excludes this possibility:

(4-B) STRATAL UNIQUENESS LAW: *for a given predicate there can be at most one constituent bearing a particular relation to the predicate* (Perlmutter and Postal, 1981).

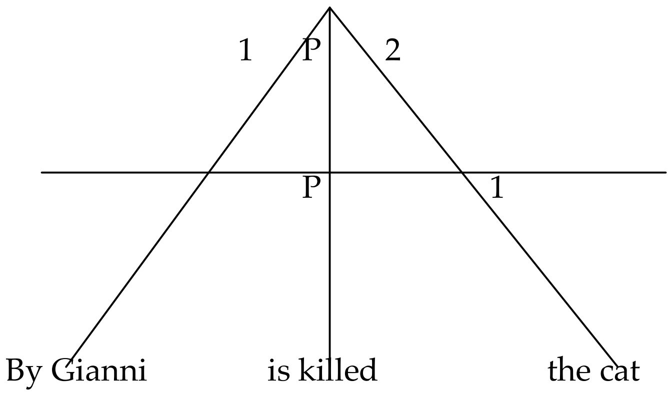
Then, the question is: what happens with the subject of (1-Ba)? RG said that is looses it's grammatical relations and become a *chômeur*. So in (1-Bb) *killed* is the predicate, *the cat* bears the 1-relation with the predicate and by Gianni has no relations and become a *chômeur*[139] (denoted as ★ in RG terms).

This is a problematic point for RG and, namely, an internal contradiction: the basic philosophy of RG is that a reason why a demoted subject (a *chômeur*) cannot enter anymore in a grammatical relation, is that it has lost its grammatical relation. But in standard RG it does not really loose its relation; it is merely shifted into a new one (cf. Harris, 1981 and Perlmutter and Rosen, 1984). This is, in a flash, the basic proposal of RG. There are of course many more operations on relations, and many more laws for which I suggest to refer to the two volumes cited above on Chicago University Press).

[139] in RG terms to be a chômeur means being without a relation, and this in turns means that one is not available for any syntactic operation based on relations. In RG a 1-relation that becomes a chômeur get a new relational sign: ~1; the same happens for a 2-realtion (cf. Perlmutter and Postal, 1981).

However, what we have just seen is enough to explain the basic ideas of RG. First, RG distinguishes two levels for (1b): the first level, before passive morphology has applied, which is identical to the level associated with (1-Bb), and another level, after passive morphology has applied. These levels are called strata. The first is called the initial stratum; the second the final stratum. There can be more than two strata; the non-initial and non-final strata are called intermediate. The RG syntactic interpretation for (1-Bb) contains both strata:

(5-B)



Assuming this representation, we may say that "there are syntactic processes which are sensitive to the relations as they are in the initial stratum and other syntactic processes which are sensitive to the relations as they are in the final stratum" (Perlmutter and Postal, 1981). For example, reflexives must be bound by an antecedent which bears a higher relation; however, languages differ whether this comparison is made at the final stratum or at some earlier stratum. However, the ranking of relations is universal: 3 > 2 > 1 (cf. Permutter and Postal, 1981).

In Russian, for example, a reflexive must be bound by some nominal whose relation is higher in the initial stratum (cf. Harris, 1981). This is why in passives a reflexive can occupy the subject position. If one moves higher in the hierarchy one is said to be advanced, and if one moves lower one is said to be *demoted* or to *retreat*. It is possible also to be raised out of an embedded sentence (this is called ascension). English or Romance passives are in this nomenclature nothing but 2-to-1 advancement. To allow this, RG postulate a sort of relational change rule, that could be simply denoted as 2→1.

It's interesting to note that Postal claims that *Antipassive* contructions[140] which on the surface looks like an object putting itself into chômage, is actually a two step sequence of the following kind:

|1 |_ | 2 | _ | 1|
|2 | |★| |★|

In an analysis of Georgian, Alice Harris (in (1981)) proposes the following successive changes:

1		3		3
2	_	2	_	1
3		★		★

This sequence of relational changes, called *Inversion* in RG terms, is like a "*rochade in chess*" (Kracht, 2000). The subject retreats to 3 putting the indirect object *en chômage*. After that, the direct object advances to 1. So it seems that there is natural tendency (not a law) to favour advancements over demotions.

However, RG proposes a law (loosign appeal... too normative!) that forbids at least some instances of demotions. A relation is a term relation if it is either 1, 2 or 3, otherwise it is a non-term relation or an oblique relation. 1 and 2 are called *nuclear*.

[140] An antipassive construction is a derived detransitivized construction with a two-place predicate, related to a corresponding transitive construction whose predicate is the same lexical item. In the basic transitive construction, the patient-like argument is realized as a direct object; in the antipassive construction, that argument is either suppressed (left implicit) or realized as an oblique complement. The term antipassive was coined to indicate that the construction is sort of mirror image of the passive: in the passive, the suppressed or demoted (using RG terminology) argument is the agent-like argument, in the antipassive, the patient-like argument. An example of a transitive/antipassive alternation is given in (ia-b).

(i) Chukchi (Kozinsky et al. 1988: 652 cited in Polinsky 2005:442 in tWAoLS)
a. aaçek-a kimit-an ne-nletet-en
youth-ERG load-ABS 3PL.SUBJ-carry-AOR.3SG.OBJ
'The young men carried away the/a load.' (transitive)
b. aaçek-at ine-nl-etet-ge-t kimit-e
youth-ABS ANTIP-carry-AOR.3SG.SUBJ-PL load-INSTR
'The young men carried away the/a load.' (antipassive)

In (ia), the transitive verb 'carry' agrees with the ergative subject and absolutive object. In (ib), the verb is marked with the antipassive prefix ine- and no longer agrees with the object; the object is now expressed by an oblique case (instrumental). A verb in the antipassive is derived from the corresponding transitive verb, often with the help of overt morphology.

(6-B) THE OBLIQUE LAW : If β is oblique, then $[\alpha \rightarrow \beta]$ implies $\alpha = \beta$.

And here are some more laws which have been proposed in the RG literature (cf. Perlmutter and Postal, 1981):

(7-B) FINAL 1 LAW : at final stratum, each predicate has a 1.

(8-B) 1 ADVANCEMENT EXCLUSIVENESS LAW : In the corse of a derivation, only once per predicate can there bea n advancement to 1.

The apparatus of RG contains also the notion of a *dummy* (as *It* in English or *il* in French, for example), which can fill a grammatical relation. They are needed sometimes to satisfy the FINAL 1 LAW. However, the following must hold:

(9-B) NUCLEAR DUMMY LAW : A dummy can only bear a nuclear relation.

And Finally we have the:

(10-B) MOTIVATED CHÔMAGE LAW: $[\alpha \rightarrow \bigstar]$ only if there is a relational change $[\beta \rightarrow \alpha]$.

So, no constituent can put itself *en chômage*; it must be pushed into chômage by another constituent moving into the relation that the constituent has.

Anyway if we know how relations are changed, we also need to know how they are assigned. RG assumes that at the initial stratum they are assigned using the *theta-grid* of the verb. Basically, verbs with identical theta-grid shall end up having identical relations assigned, or more concretely, if a theta-role is assigned role A with respect to one predicate it shall get role A also with respect to any other predicate. This principle is called the Universal Alignment Hypothesis (UAH).

It is stated as follows (originally proposed in Perlmutter and Postal (1984); see also the discussion in (Perlmutter & Rosen, 1984)):

UNIVERSAL ALIGNMENT HYPOTHESIS.

There exist principles of universal grammar which predict the initial relation borne by each nominal in a given clause from the meaning of the clause.

Thus, particular thematic relations and theta roles map on to particular positions in the sentence. For example, in unmarked situations agents map to subject positions, themes onto object position, and goals onto indirect objects.

The thematic relations are mapped directly into argument position based on the following hierarchy: *Agent < Theme < Experiencer < [Others]* (cf. also paragraph 1.5 for a presentation of Fillmore's Case Grammar).

Mark Baker adopted this idea into GB theory in the form of the Universal Theta Assignment Hypothesis (or UTAH) (Baker, 1988; cf. also Belletti and Rizzi, 1988 for *psych verbs*).

A different approach to the correspondence is given in Hale & Keyser (1993) and Hale & Keyser (2001); as we have seen in Chapter 4, in Hale & Keyser proposal there are no such things as underlying theta roles or even thematic relations (cf. also Moro, 1997). Instead, the interpretive component of the grammar identifies the semantic role of an argument based on its position in the tree. It would be fascinating to develop these issues in further graph-based researches.

APPENDIX C

A sketch for the strong graph hypothesis: Tagalog clause structure.

I have argued in a footnote of chapter 5 that Tagalog[141], as many Austronesian languages[142], is very puzzling and stimulating (and useful in questioning someone theoretic assumptions). So I want to test with this language the prolegomena (of a prolegomena) of a *strong* graph hypothesis in which natural language is a linear (connected & rooted) graph.

Let's start from a simple Tagalog sentence, a di-transitive construction:

(c-1)
Nagbigay *ng* libro *sa* bata *ang* lalake. Tagalog
Gave acc book dat child nom man
'The man gave a book to the child.'

Here is a possible derivation, given the principles in 5.2.2, of the example above.

Note that, for our purpose, to use a bottom up or a top down approach makes no difference. My idea (as I have explained in the course of the work) is that a bottom-up derivation is more probable as the leading path for the computation, but I give here a top-down account for explanatory convenience.

(c-2)
INITIALIZE SEQUENCE →
SELECT a Lexical Item as Vertex (*V*): *Nagbigay;* [*Nagbigay* checked as *V*; selectional/sub-categorizational requirements of *V* registered; *V* available for operations] →
PRIORITIZE an Edge (E)

[141] Tagalog is one of the major languages of the Philippines (It is the most spoken Philippine
language in terms of the number of speakers). The word Tagalog derived from tagá-ílog, from taga´- meaning "native of" and ílog meaning "river", from Filipino Muslims of that era thus, it means "river dweller." Tagalog is a VSO (marked, but common VOS) language, in which there is no fixed position for the absolutive. Rather, this DP tends to appear in its base position: external arguments immediately following the verb; themes following the external argument; and goals following themes.

[142] The Austronesian languages are a language family widely dispersed throughout the islands of Southeast Asia and the Pacific, with a few members spoken on continental Asia.

E features: operator *Ng*{Obj feature} implies (*V*,*E*) to form a relation {*formRel*} with an *Obj V′* [selectional/sub-categorizational requirements of V filled] →

SELECT Lexical Item as *V′*: *Libro;*

[*libro* checked as *V′*; selectional/sub-categorizational requirements of *V′* registered; the *cluster {V,E,V′ = Nagbigay ang Libro}* available for operations] →

PRIORITIZE an E′ →

E′ features: operator *s* {*Term feature*}, implies *(V,E,V′,E′)* to *formRel* with a *Term V′′* [selectional/sub-categorizational requirements of V′ filled] →

select Lexical Item: *bata;*

[*bata* checked as *V′′*; selectional/sub-categorizational requirements of *V′′* registered*;* the cluster *(V,E,V′,E,V′′= Nagbigay ng libro sa bata)* available for operations] →

PRIORITIZE an E′′ →

E′′ features: operator *ang*{Subj feature} implies *(V,E,V′,E,V′,E′′)* to *formRel* with a Subj V′′′ [selectional/sub-categorizational requirements of V′′ filled] →

SELECT Lexical Item: *lalake;*

[*lalake* checked as *V′′′*; selectional/sub-categorizational requirements of *V′′′* registered*; the cluster (V,E,V′,E,V′,E′′,V′′′) available for operation;*

[selectional/sub-categorizational requirements of V′′ filled]

The cluster (V,E,V′,E,V′,E′′,V′′′) is a connected graph: Recognized as grammatical.

[selectional/sub-categorizational requirements of V′′′ checked]

no further operations needed / allowed. →

TERMINATE SEQUENCE.

Refining the system

Note that in Tagalog the NPs normally follow the verb and can occur in any order. The Case *operator/licensers* labelled above as *Subj/Obj/Term* features have only a "cultural" foundation. As the examples below try to show, sentences that means (fundamentally) the same thing, in Tagalog, can be expressed in different ways:

a. *Mag*-bibigay *ang* babae *ng* bigas *sa* bata.
act-will.give nom woman ntl rice dat child
'A/The woman will give some rice to the child.'

b. *I*-bibigay *ng* babae *ang* bigas *sa* bata.
und-will.give ntl woman nom rice dat child
'A/the woman will give some rice to the child.'

c. Bibigy-*an* *ng* babae *ng* bigas *ang* bata.
will.give-rcp ntl woman ntl rice nom child
'A/the woman will give some rice to the child.'

In each of these examples, the verb bears an affix (or *suffix*) which signals the required operations: in these examples, *mag*- if it is what we may define as the agent, *i*- if it is the patient, and -*an* if it is the recipient. This could be *construed* as a kind of *agreement*.

A theoretical assumption made in chapter 5 has been the one to consider an edge as the (possible) habitat of many features (until saturation occurs), *binded* to adjacent (or distant, thanks to a *recoverability* principle) lexical elements (vertex).

In the example I have shown above, it is possible to consider the "topmost edge" to be the ground for {*mag-ang*; *i-ng* or *an-ng* respectively for a; b; c}. Now, I ask myself if an edge might be *structurally* positioned before the root vertex (implying a sort of *dummy* root vertex with no lexical content: a specie of graph's EPP).

I implicitly assume that at a level of the morphology-syntax interface (and also phonology-syntax interface), in a linear syntactic graph, many fine-grained operations could take place, and an edge-function is allowed to *switch* with/from an adjacent vertex.

In the present theory, this fact is not an instance of movement (remember from chapters 3 and 5 that all the operations must be strictly local and movement, given our tentative representation, is not logically allowed), but a sort of *affix-hopping* phenomenon, driven from an adjacency condition.

Think to Romance determiners. In most of Romance languages definite articles precede the noun, but I assume that this is a *derived* sequence and that the Romanian D, who follows the N represent the non-marked instance (cf. Giusti, 1992; Cinque, 1995): D is base-generated as an edge that follows the lexical vertex (N) (note that in a cross-linguistic survey, in languages with *ouvert* determiners, more than an half follows the noun, cf. Comrie *et al.* 2005).

The next construction taken from Tagalog is reflexivization; it seems that the ability to be the antecedent of a reflexive pronoun is a property of subjects, *albeit* not an exclusive one.

(c-3)
a. Nag-iisip *sila* *sa* kanilang sarili. Tagalog
act-think.about 3pl-nom dat 3pl-gen self
'They think about themselves.'

b. In-iisip *nila* *ang* kanilang sarili.
gl-think.about 3pl-ntl nom 3pl-gen self
'They think about themselves.'

The bizarre thing here is that the reflexive pronoun is marked by *ang* in (c-3b), which would make it a *nominative* Case marked reflexive, something that is very rare cross-linguistically.

Anyway, this is congruent with out (too permissive?) thesis. The computational system, given a spelled-out operator (which encode the standardized alignment(s) of features), may induce a Probe/Goal (still adopting a prominent metaphor of Minimalism) relation between (among) lexical vertexes. An edge-relational system may account the Case discrepancies of languages such as Tagalog. For example, considering (c3-b) if a the *non-nominative* Case marked item in the linguistic *repertoir*e of a given natural language does not automatically rule out the possibility for that item to be the antecedent for an anaphora (this possibility is attested in its selectional/subcategorizational requirements), then an operator that carries the nominative feature may surface to rescue the interpretability of a sentence, driving the selection of the following word from the lexicon (and filling the selectional requirement of the previous vertex).

Let's now turn to Relativization. In Tagalog a constraint occurs: the *head* must be interpreted as the *nominative* argument in the relative clause. This is illustrated in (c-4), based on examples from Van Valin (2003: 97).

(c-4)
a. ang babae-ng mag-bibigay ng bigas sa bata.
nom woman-lnk act-will.give ntl rice dat child
"the woman who will give some rice to a/the child"
b. *ang babae-ng i-bibigay ang bigas sa bata.
nom woman-lnk und-will.give nom rice dat child
c. *ang babae-ng bibigy-an ng bigas ang bata
nom woman-lnk will.give-rcp ntl rice nom child
d. ang bigas-an i-bibigay ng babae sa bata.
nom rice-lnk und-will.give ntl woman dat child
'the rice that a/the woman will give to a/the child'
e. *ang bigas-an mag-bibigay ang babae sa bata
nom rice-lnk act-will.give nom woman dat child
f. *ang bigas-an bibigy-an ng babae ang bata

nom rice-lnk will.give-rcp ntl woman nom child
g. ang bata-ng bibigy-an ng babae ng bigas
nom child-lnk will.give-rcp ntl woman ntl rice
'the child that a/the woman will give some rice'
h. *ang bata-ng mag-bibigay ang babae ng bigas
nom child-lnk act-will.give nom woman ntl rice
i. *ang bata-ng i-bibigay ng babae ang bigas
nom child-lnk und-will.give ntl woman nom rice

In each of the grammatical examples, the head is interpreted as the nominative argument within the relative clause. In this construction, then, the nominative NP counts as the *subject*; the relevant thing here is that, in a graph oriented interpretation, we may see that if a *linker*-edge drives for the formation of a relative clause, then the edge feature (+nom *ang*) is ruled out and no interpretations are available for (embedded) sentences in which this feature (+nom, or better the *ang* operator) surfaces.

This is a relevant fact of a function/feature driven syntax, even if it may seem trivial or immediate: the availability of a feature necessary implies the impossibility of some other features { + *plur* implies - *sing*; + *masc* implies – *fem*; + *relative linker* in Tagalog implies – *ang mopheme* in the embedded clause}.

An interesting situation arises when constructions are combined. Consider the examples in (c-5) involving relativization and reflexivization (from Van Valin, 2003).

(c-5)
a. B-um-ili ang babae ng bigas para sa kaniyang sarili. Tagalog
act-bought nom woman ntl rice for dat 3sggen self
'The woman bought rice for herself.'
b. B-in-ili ng babae ang bigas para sa kaniyang sarili.
und-bought ntl woman nom rice for dat 3sggen self
'The woman bought the rice for herself.'
c. Binilh-an ng babae ng bigas ang kaniyang sarili.
bought-rcp ntl woman ntl rice nom 3sggen self
'The woman bought rice for herself.'
d. ang babae-ng b-um-ili ng bigas para sa kaniyang sarili
nom woman-lnk act-bought ntl rice for dat 3sggen self
'the woman who bought rice for herself'
e. ang bigas-na b-in-ili ng babae para sa kaniyang sarili

nom rice-lnk und-bought ntl woman for dat 3sggen self
'the rice that the woman bought for herself'

The crucial examples here are the relative clauses in (c-5d) and (c-5e): *babae* 'woman' in (d) and *bigas* 'rice' in (e) are the heads of the relative clauses and therefore are interpreted as the nominative NP within the relative clauses. *Babae* 'woman' is the antecedent of the reflexive NP in both sentences. In (c-5d) both reflexivization and relativization pick out *babae* 'woman' as the subject of the embedded clause, but this is not the case in (c5-e). The relativization construction identifies *bigas* 'rice' as the subject of the embedded clause, as does verb agreement, whereas the reflexive construction points to *babae* 'woman' as the subject of the embedded clause. Which NP is the subject of the embedded clause in (c-5e)? There appear to be two subjects, and this is precisely the problem which Tagalog-type systems raise. Some constructions identify the *ang*-marked NP as the subject, while other constructions pick out an *agent* NP, regardless of whether it is marked by *ang* or *ng*, as the subject. The proposal I have sketched out for the system, even if somewhat *too* easy, is able to explain this kind of things using features/functions (and features availability & constraints) as devices that allow syntactic *boundaries*. The distribution of features in the examples in (c-5) is congruent with the ones discussed for (c-4).

This a, at least, a possible way to analyze a system with *split* subject properties. Tagalog is a system that presents a grammatical *habitus* which differs in important and revealing ways from the familiar Romance (and Germanic) systems.

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